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The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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Custom of the Trade

When hearing commercial actions, His Majesty's judges, whilst not basing their judgments on Custom of the Trade, do certainly take cognisance of them before forming their conclusions. Just what credence can be given as to what is the Custom of the Trade is interesting. We recently consulted a district foundry employers' association on a specific question; a questionnaire was sent along to a few of the prominent members of its council with the surprising result that our personal interpretation of what actually was the Custom of the Trade was supported by three firms, contradicted by three firms, whilst a seventh "sat on the fence." Yet the query was the simple one of whether, when a customer orders castings and after a period of trading closes the account, he can demand patterns furnished by the foundry. Our view is that patterns, like jigs and fixtures in the engineering trade, have nothing whatever to do with the customer, even though he is charged something towards the provision of these. We enunciate this because, in the course of their business, the foundry may hazard that the type of order is non-repetitive and construct a skeleton pattern, or they may think that the order is just the first of a series and may create a pattern guaranteed to last for ages. This pattern may be of greater value than the order, and to demand that it should be presented free of charge to the customer is not equitable. The fact that a foundry may demand some monetary recompense towards the partial cost of a pattern is strong indication that the latter is definitely the property of the foundry. Apart, however, from the merits or demerits of this particular case, it is obvious that the foundry industry should create some unified system of conducting its general business; otherwise every quotation set out would have to embody half the law of contracts as interpreted by the seller as pertaining to his line of manufacture. Whether one likes it or not, there are implied warranties, interpretable by Courts of Justice, with all goods sold, unless specific disclaimers are indicated and agreed to by the purchaser. Owing to the exigencies of business, these implied warranties often need limiting, and this precaution finds expression, for example, in the established custom of limiting a foundry's liability in the case of the furnishing of a defective casting to its replacement by a satisfactory one. There is a real need for the drawing up of a set of "fair trading conditions" in a manner somewhat similar to, but much less comprehensive than, those insisted upon by railway companies, insurance houses, electricity suppliers and so forth. At the moment sale conditions in many respects differ not merely from district to district but even in the same locality.

Shortage of Managers—3

In a final consideration of this question we wish to refer to the way in which foundry owners should be interested in training schemes, regardless of whether they have any immediate use for them. At present the majority of employers, when faced with the necessity of replacing a key man who either retires or proceeds to pastures new, have no alternative but to acquire another man from some other foundry. Indeed, many men change their employment in this way in the normal process of improving their position. At best, what may be described as a short-term overlap is arranged, during which a new man takes over. The most far-sighted employers, however, and naturally those with the largest responsibilities, take care that no major post is without an appropriate understudy, and the idea of training men for an organisation within the establishment is steadily gaining ground. The grouping of foundries is also facilitating both the transfer and promotion of leading men within the organisation as a whole, and the development of more highly specialised foundry engineers and metallurgists. In the course of time these posts are likely to go to men who have had training in one or other of the courses mentioned in our last issue.

Since these schools increase the reservoir of trained men available, all firms operating foundries should find it to their interest to assist them, regardless of whether they have any immediate interest in a particular candidate. This would, of course, be easier if the industry were fully organised, and as things are there are bound to be differences in outlook in different establishments, some taking the longer and some the shorter view. We are here urging the longer view, in the interests of the industry as a whole. In the case of neither of the courses referred to is the industry asked to contribute more than a fraction of the cost concerned. Since much of the initial preparation for such courses is carried out in the technical colleges, principals and teachers should exploit to the full the possibilities of their classes as qualifying their better students in part for the higher work, the successful termination of which will reflect credit on everybody concerned and be to the benefit of the industry.

A Magnetic Thickness Gauge

The magnetic thickness gauge shown in Fig. 1 measures the thickness of iron and steel walls by direct contact with one side only. A powerful electro-magnet is brought in contact with one of the walls to be measured. The thickness, magnified many times, is read on the scale of a very sensitive meter. The illustration shows the standard form of magnetic gauge as used in measuring the thickness of the walls of automobile cylinder blocks. The cylindrical shell at the right contains the magnet and energising coil. The two pole pieces are shown extending slightly from the shell near the ends. They are ground carefully in a special grinding fixture to conform to the cylinder bore.

The meter shown at the top in front is mounted in the handle casting and carries a dial with a centre zero mark. A reset knob at the bottom of the meter case is used to obtain the proper setting for any given master sleeve which is used as a standard of comparison for the cylinder block which is to be inspected. The scale just above the dial is detachable, and is marked with the rejection limits for the cylinder model to be inspected. A reading pointer shown

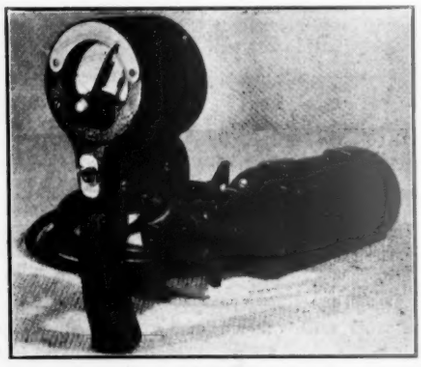

Fig. 1.—Magnetic Thickness Gauge.

extending over the dial to the limit scale is set to the required limit for ease of reading.

A selector switch shown just below the dial permits the operator to take readings of the thickness of the wall at either pole piece. This is necessary in order to cover the full length of the bore. The master switch controlling the current which energises the magnet is of the trigger type, located in the handle casting, and can be easily operated when the gauge is inserted in the cylinder bore.

The accepted practice is to inspect each bore of the first castings of a new model of cylinder block very carefully at top and bottom, around the complete circumference, and to make up a detailed chart of the results as a guide for the inspector. In nearly all cases the variations in thickness are found to be of the same character in all the blocks. These results will guide the foundry in making pattern and corebox changes and the machine shop in changing the setting of the block in the jigs.

In production each block should be inspected at the points where thin spots are most likely to be found as indicated by the reference chart, and individual blocks should be thoroughly inspected at regular intervals. A cylinder wall, light on one side and heavy on the other, may be round when cold and oval when heated by normal operating conditions. This causes oil and pressure leakage, and can be detected by the magnetic thickness gauge, not by gauging the bore for roundness.

Those most experienced in machining, lapping and honing cylinders agree that it is difficult, if not impossible, to obtain a perfectly round bore when the cylinder wall is not uniform in thickness. The unusually high percentage of endorsements which the magnetic thickness gauge has received and the number in use by leading car and engine manufacturers, indicate that the gauge is a worth-while addition to the inspection equipment of any engine manufacturer. This instrument is manufactured by Commercial Engineering Laboratories, 4612, Woodward Avenue, Detroit, Michigan, U.S.A.

Notes from the Branches

Lancashire.—The programme of the meeting to be held in the Engineers' Club, Albert Square, Manchester, on Saturday, March 7, should prove to be an interesting departure from the customary full-length lecture. Four local members have consented to provide "ten minute" Papers, and as the subjects are varied the Papers and discussions should provide material for a wide range of interest. The lecturers and their subjects are:—(1) Mr. J. Eric Garside, B.Sc. (Tech.): "Some Notes on the Gating of Castings: (*a*) Importance of correct gating; (*b*) defects due to incorrect gating; (*c*) types of gates, and (*d*) possibility of calculating the size of the gate"; (2) Mr. J. Pattison, A.M.C.T.: "Principles of Moulding in a Job which I Considered Interesting"; (3) Mr. J. W. Potts: "The Foundryman of the Future," and (4) Mr. Geo. Whittaker: "A Brief Survey of Sand Testing Apparatus as recommended by the British Cast Iron Research Association."

Burnley Section.—On March 10, in the Municipal College, Ormerod Road, Burnley, at 7.15 p.m., there will be held the annual general meeting, followed by a short Paper by Mr. D. Malone, entitled "The Influence of the Various Metalloids on Cast Iron."

Scottish Branch.—Competitions have been completed in the Senior and Junior sections of the Surtees Memorial, which this year were held in Scotland. In the Senior Grade the Gold Medal and first prize has been awarded to Mr. Matthew Russell, foreman patternmaker with Drysdale & Company, Limited, Yoker, Glasgow. In the Junior Grade the Silver Medal and first prize has been awarded to Mr. Douglas Robertson, of Renfrew, whilst prizes have been awarded to Mr. James McQuilken of Glasgow, Mr. James Shaw of Renfrew, Mr. James Cleary of Springburn, and Mr. Alexander Harris of Glasgow.

The medals and prizes will be handed to the winners by Mr. Tom Makemson, Secretary of the Institute, at the meeting of the Scottish Branch to be held in the Royal Technical College, Glasgow, on March 14.

At the recent Winter Conference organised by Prof. Piwowarsky at the Technical High School of the Foundry Institute at Aachen, a Paper was given by Mr. J. G. Pearce, Director of the British Cast Iron Research Association, on "Progress in British Research on Cast Iron." Prof. Piwowarsky and Prof. Nipper desired to send greetings to a number of English friends.

The Air Ministry announces that the present expansion of the Royal Air Force affords an opportunity to well-educated boys to enter the Service in large numbers. No less than 1,000 boys will be entered for training in the late summer; of these, approximately 800 will be required in August for training as aircraft apprentices and the remaining 200 in September as boy entrants. No previous trade experience is required by candidates. Applicants for apprenticeships must be at least 15, but under 17 years of age on August 1, 1936, and for boy entrants between 15¾ and 17¼ on September 1. Full particulars of both schemes can be obtained from the Inspector of Recruiting, Royal Air Force, Victory House, Kingsway, London. W.C.2.

Better Spelter Outlook

By "Onlooker."

The end of last year found spelter in a very depressed condition, with the quotation on the London Metal Exchange standing at about £14 10s. per ton. There was every prospect of a further decline, demand was poor and nobody had much faith in the future. Actually there was a further fall to £14 3s. 9d., but towards the end of January an improvement set in, which carried the price up to £16 and even beyond it before March came in, this figure being within striking distance of lead values, a real achievement in view of the fact that spelter had apparently dropped a long way behind the other metal, which normally it ought to surpass. The change-over in the relative values of these two metals was, of course, due to the excellent and prolonged demand for lead, coupled with the fact that no artificial measures of restriction had been adopted, whereas in spelter curtailment of production was in force, with no certainty, however, that this would be adhered to.

German Domestic Production

The truth of the matter is that lack of really reliable information had led to the spelter situation being construed as being worse than it actually was, for all sorts of rumours of increasing production were current and, of course, it was known that Germany was importing less, being in a position to supply more of her needs through the starting up of the large plant at Magdeburg, which it is now understood has a modest surplus available for export. Actually there is no particular sign of excessive stocks anywhere, and although it must be confessed that demand from the consuming trades is not good, selling pressure is not much in evidence. This is especially interesting if it be remembered that by the change over from an *ad valorem* duty of 10 per cent. on foreign spelter to a fixed rate of 12s. 6d. per ton the way was opened for continental brands to come into this country. As a matter of fact, comparatively little has made its appearance, for apparently the producers shut out of the United Kingdom for more than three years, had found other outlets for their metal, and are satisfied to carry on without bothering to try to effect a re-entry into this market.

Rumours of Cartel Revival

The recent strength in spelter has primarily been due to reports that the cartel is likely to be revived, and although confirmation is lacking of this, it does seem likely that unofficial conversations among producers have taken place. To bring this producers' pact into being again is not going to be easy, for there are tariffs, exchange problems and special local conditions to contend with, all of which combine to make joint action difficult if not impossible. Why should Germany, for example, concentrating as she is on keeping down imports and fostering home industries, consider joining an international arrangement of which the aim would almost certainly be a cutting down of output? Probably British producers would adopt a very similar attitude unless, of course, a really adequate quota were granted, and doubtless this is where the trouble would arise. Certainly at a time like the present, when the whole question of rearmament and home defence is to the fore, it is unthinkable that anything should be done to limit even to a small extent the activity and development of the industry here. All things considered, it seems doubtful whether anything will come of the movement towards bringing the Zinc Cartel back again, and for this reason some reaction from the present price level would occasion no surprise, but nevertheless the outlook is far from gloomy.

New Continuous Casting Plant at Derby

INTERNATIONAL COMBUSTION COMPANY'S RECENT DEVELOPMENT

Recent experiences have indicated that real benefits are to be derived from allowing a description of a foundry to appear in THE FOUNDRY TRADE JOURNAL, as it is found that, after the passage of a few years, such progress is made that a fresh description is warranted. Into this category enters the foundry of the International Combustion Company, Limited, of Derby. This works was described and illustrated in our issue of September 19, 1929. At that time the sand-preparing plant was thoroughly efficient, the moulding machines were working rapidly and turning out as many as 200 boxes a day, but this involved much walking. Even at that time we discussed with the management the installation of mould-handling machinery and now, on revisiting the plant, we find that the whole foundry has been revamped and a continuous-casting plant has been installed.

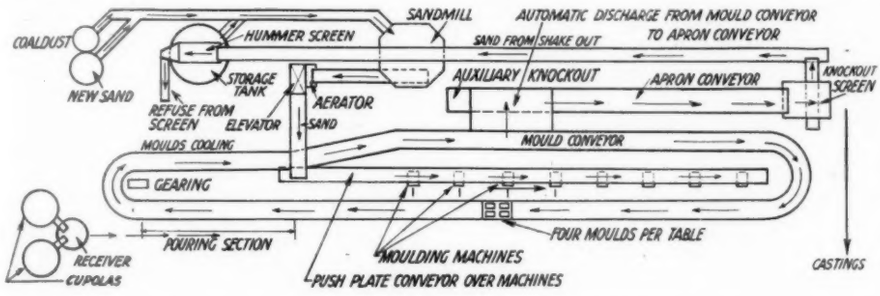

FIG. 1.—DIAGRAMMATIC LAY-OUT OF THE CONTINUOUS-CASTING PLANT.

Melting Plant

Two new cupolas of 3 ft. 10 in. dia., incorporating the balanced-blast system, have been built to furnish iron for the continuous plant. The iron from either cupola runs into a 10-cwt. receiver and from this is handled by means of ladles slung from a double monorail looped so as to give about 20 ft. of pouring length before returning on a parallel line space about 7 ft. away.

The Continuous Plant

An endeavour has been made to make this plant as elastic as possible, and though in general it handles boxless castings, provision has been made to handle boxed moulds and, moreover, the plant is made to supply at least a portion of the sand required for a special job not enclosed within the area bounded by the mould conveyor and also facing sand for a section of the jobbing floor. The general lay-out of the new plant is shown in Fig. 1. The boxless moulds are discharged from the mould conveyor by the automatic tilting of its constituent tables as they pass a definite position. The table tops are flanged so as to retain the moulding board, as is clearly shown in Fig. 2. Should the plant be making boxed castings the tripping mechanism is cut out, and the boxes are allowed to continue their journey to their own knock-out. Again, some of the castings made carry delicate gills and these, although boxless, are not allowed to tumble down the inclined plane for fear of damage, but are lifted off by hand and knocked out over a grid feeding an apron conveyor carrying the main supply of sand from the knock-out. The main body of sand and castings falls on to this 30-in. wide apron conveyor. The conveyor, which runs at 30 ft. per min., and has a capacity of 45 tons per hr., rises to about 20 ft. before spilling its contents on to a jarring knock-out screen, shown in Fig. 3. Here the castings automatically pass over the screen and drop into waiting containers. The sand falls through the screen on to a short length of belt which incorporates a magnetic pulley for the removal of tramp iron, and when boxed castings are being made the sand and castings are knocked out over a grid in the proximity of the main knock-out. The sand falls on to a short length of belt feeding the belt beneath the screen. The latter belt spills on to the main sand belt. There is a distinct absence of dust at the knock-out and indeed the whole plant is commendably free from this trouble, the low ratio of iron to sand being no doubt a contributory factor. The main sand belt which is troughed, is about 100 ft. long and 24 in. wide, and rises to about 25 ft. above floor level, where it feeds a 5 ft. long by 4 ft. wide Hum-mer screen of the single-surface type set at an angle of 33 deg. slope. The feature of this interesting plant, which is an open-body, single-surface machine equipped with a V-16 vibrator, is that it is operated by a metal rectifier, arranged for wall mounting, comprising a half-wave rectifier mounted in an angle-iron frame protected by expanded sheet-metal covers. The rectifier is connected to a 230-volt single-phase a.c. supply and has an output of approximately 110 volts at 4 amps.

The output from the rectifier consists of a series of unidirectional impulses occurring at the supply frequency, which in this case is 50 cycles per min.; thus 3,000 strokes per min. are imparted to the armature of the Hum-mer vibrator, which produces an intense vibration especially suited to fine-mesh screening. No make-and-break contacts requiring extensive maintenance are necessary.

Vibration to the screen cloth is imparted through an electric vibrator by means of a bracket fixed to the armature post, which, in turn, is bolted to spring steel strips running the length of the cloth. The intensity of vibration is regulated by a hand-wheel to give either intense or medium vibration, according to material to be screened. The vibrator consists of an electro-magnet and an armature, and the alternation of the current pulls up the armature and releases it at speed.

Within the vibrator are two steel striking blocks, and each vibration on the upstroke is brought to a sudden stop by these striking blocks, which impart a sharp jar. This jar is very effective in keeping the meshes clear. The force of the vibration tosses the coarser particles up and away from the screen and the fine material passes through the screen openings. The weight of the coarse particles falling assists the separation by keeping the fines in contact with the screen. With this type of screen the motion lifts the material only a short distance from the cloth in a vertical direction and the entire screen area is properly employed.

The material not passing through the screen drops down a shute to fill a barrow ready for removal. The sieved sand fills a 30-ton capacity storage hopper, the bottom of which is formed of a 6-ft. 6-in. dia. rotatable table driven by a 4-h.p. motor. An adjustable plough scrapes off the sand to feed an inclined belt which spills into the sand mill. This belt has already received its quota of new sand and coal dust. These are fed through gratings in the floor and fill small hoppers, also supplied with rotating-table bases and from which the ingredients are ploughed off on to the belt below ground. This belt is inclined; at floor level it receives the

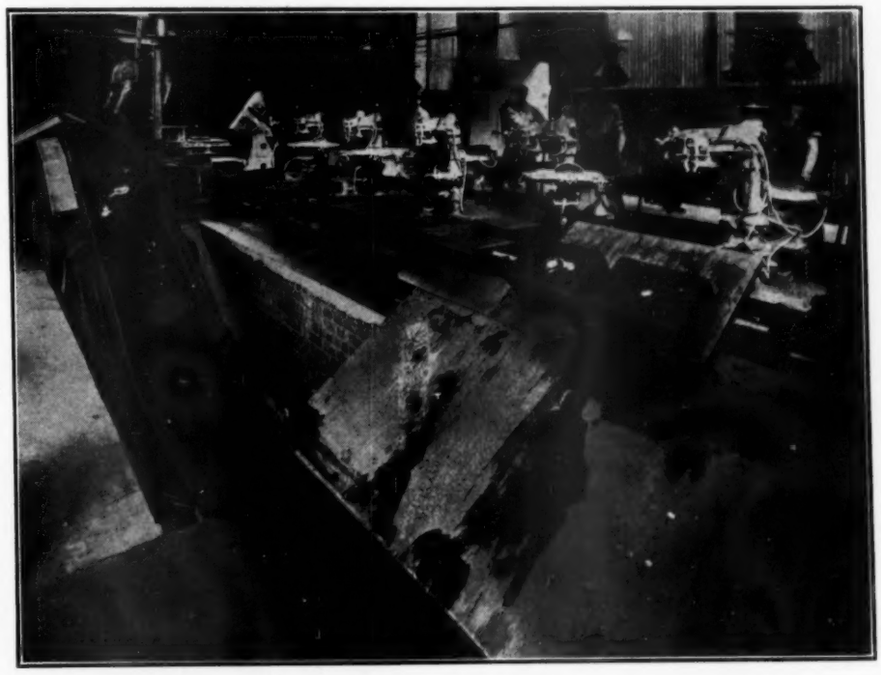

FIG. 2.—THE AUTOMATIC DISCHARGE OF THE MOULDS FROM THE CONVEYOR. THE OPERATION OF PICKING THE CASTINGS FROM THE SAND HAS NOW BEEN ELIMINATED.

sand from the storage hopper, and it finally discharges the mixture into a 30-ton per hr. capacity Baillot continuous mill. This mill has previously been described and illustrated. It discharges centrally on a 20-ft. length of inclined belting, which feeds the boot of a 12-in. bucket elevator, running at 220 ft. per min., giving a capacity of 30 tons per hr. This is totally enclosed, so as to give a chimney-cooling effect. The sand discharges on to a short length of 24-in. wide belt feeding an aerator of the type which throws the material at high speed from a 24-in. dia. pulley running at the rate of 240 r.p.m. through a hanging nail comb. It has not been thought necessary to make this apparatus to jar, as is sometimes the case, and no difficulties have arisen. The sand falls on to a flat 24-in. belt., running at 100 ft. per min., to feed the prepared-sand conveyor. This is of the push-plate type, being 22 in. wide, with the plates set at 24-in. pitch. It runs at 60 ft. per min. This feeds nine hoppers situated directly above the moulding machines; and also a conveyor running at right angles, which carries four hoppers; there is an overflow hopper for yielding a supply of sand for the jobbing foundry. This conveyor, at right angles, constitutes what may well prove to be the nucleus of the mechanisation of jobbing foundries. In this case, the three hoppers are situated over a specially-long Zimmermann making economiser headers. As with the main plant, there is an overflow shute, but in the latter case it feeds, as is shown in Fig. 5, the short length of conveyor leading from the knock-out to the main supply belt.

The hoppers have two sides in the vertical plane and two set at an angle so as to avoid sticking, a problem not so far encountered. They have the usual clam-type closure. The machines set within the mould conveyor are all Bonvillain and Ronceray jolt squeezers, taking patterns up to 17½ by 11½ in. They are set on 7-ft. 2-in. centres.

Fig. 3.—The Knock-out is now somewhat changed as the Castings are separated at this Screen, since altered for Automatic Discharge.

The Mould Conveyor

The mould conveyor can be adjusted to operate at speeds ranging between 5 and 15 ft. per min. It is made up of 46 tables, measuring 3 ft. by 3 ft. 6 in., set at a height of 2 ft. from ground level. When making boxless castings, each table carries four moulds. The plant is turning out at present some 2,000 to 2,500 moulds per 9-hr. day, weighing up to 22 tons. When the conveyor nears the pouring end, the loop narrows, and at the beginning of this construction weights received by a length of gravity conveyor are placed on each mould. Four casters working on twin loops teem up the castings from monorail-suspended ladles of 100-lb. capacity. After being cast, an operator removes the weights and passes them back by means of the roller conveyor already referred to.

Sand Control

Each day about 3 tons of new Mansfield or Stourport sand is added, together with a 2.5 to 3 per cent. of coal dust. The mixture is controlled at 5.2 per cent., being added, of course, in the mill. An average B.C.I.R.A. standard compression figure is 105, whilst a typical screening test is

Fig. 4.—This Hum-mer Screen deals with 30 tons of Sand per hr.

+	20 mesh	6.5
+	40 „	6.3
+	60 „	17.2
+	100 „	42.4
+	200 „	21.5
−	200 „	6.1

The loss on igition is 2.6 per cent.

General Features

Push-buttons have been installed at convenient points about the plant, to operate in case of emergency. The total horse-power installed for the operation of the plant is 67.5, which includes 35 h.p. requisite to drive the sand mill. There is no spillage conveyor beneath the moulding

Fig. 5.—General View of the Mould Conveyor.

machines, which makes the operators more careful in the use of sand, as spillings have to be shovelled up by them. Provision has been made for the installation of moulding machines outside the mould conveyor and exactly opposite the existing ones. This plant (about one-sixth of the total area of the foundry) takes up a a space roughly measuring 120 ft. by 48 ft.

Fig. 6.—View of the Machines enclosed by the Mould Conveyor.

Conclusions

We wish to express our sincere thanks to Mr. F. G. Penny, managing director, and Mr. F. Gudgeon, works manager, for the help they have accorded us in assembling the data necessary for the preparation of this article.

The 1936 Census of Production and the Foundry Trade

The idea underlying the 1936 census of production is to secure general statistics concerning the position of the trades of the United Kingdom, and it has been thought that an article indicative of the Government's power in this respect and the obligations upon firms in the foundry industry might be useful. The making of returns by firms is obligatory under penalties, but on the other hand, the Government are prohibited from making use of, or publishing, individual returns, and every person engaged in the survey has to make a declaration of secrecy, and if any information is divulged it is an offence, punishable by fine or imprisonment or both. Powers are given the Board of Trade under both the Import Duties Act and the Census of Production Act, but under the Import Duties Act a list of trades for which returns are required must be published. For this 1936 survey of 1935 production, under that Act, particulars of all dutiable goods under that Act must be returned, as well as under all other duty-imposing Acts. Under the Census of Production Act, firms coming under the Factory and Workshop Acts are required to make a return, as well as other specified trades. Therefore, this census is the most comprehensive yet undertaken, as practically all trades come under this survey.

If a firm's products are covered by both Acts, only one return is required nevertheless; but it should be noted that if a firm is concerned also with non-dutiable goods a return must be made under the Census of Production Act, even though a form has been completed under the other Act. The information required under both Acts is practically the same; thus quantity and cost of materials used, and of fuel and electricity consumed, and quantity and value of output, with the number of persons employed, are the main questions. Under the Census of Production Act, the Board have power to ask for any other information considered necessary to complete the return, of a like nature, but amount of wages paid cannot be required. All firms are required to make a return, but if the number of employees during the survey year has not exceeded ten persons, then only Parts A and B of the form received need be completed; heads of firms and clerical staff are included in this computation of ten persons or fewer, but anyone engaged in merchanting and factoring are excluded.

Part A is a declaration of the accuracy of the information supplied, and Part B relates to the number of employees, if ten or fewer, and the nature of the business. The year of survey is the year ending December 31, 1935, but if a firm's financial year ending is some other date, that date can be substituted, providing it is not earlier than April 7, 1935, or later than April 8, 1936. As regards the number of employees, there are two questions, one being merely an entry for one date, of just the total of all employees; in the other there is a sample date, that for the foundry industry, being October 12, 1935, and the totals are here divided between male and female; 18 years and over, and under 18 years; and between workpeople (wage-earners) and administrative, clerical and technical staff. As regards output, the descriptions for which a return is required are printed on the form and much trouble is saved by seeing that the right form is received; then written-in entries will only relate to the net selling value and quantities where required. The information is all totals, value being in total pounds, no fractions required. But there is a space for any goods not designated, but as stated if the proper form with printed descriptions be used, much trouble is saved. If any form is required by a firm coming under the survey, the Board will supply it free of charge on request.

It might be useful to note that premises which come under the Factory Acts are those with operations such as making, altering, repairing, ornamenting, or finishing, or adapting for sale any article, or part of an article, so it will be seen that it is not all complete manufacturing operations that come within the survey. But any section of a firm where merchanting and factoring only take place, should be excluded from any particulars requested; merchanting and factoring is defined as meaning merely buying and selling with no intervening process taking place.

The following are forms of trade interest:—

Iron and Steel Trade: Foundries, Form No. 42; Blast Furnaces, Form No. 40; Smelting and Rolling, Form No. 41.

Chain, Nail, Screw and Miscellaneous Forgings Trades: Form No. 43.

Tinplate Trade: Form No. 44.

Wire Trade: Form No. 45.

Tool Making and Cutlery Trade: Form No. 46.

Hardware, Hollow-ware, Metallic Furniture and Sheet Metal Trades: Form No. 48.

Small Arms Trade: Form No. 49.

Mechanical Engineering Trades: Form No. 50.

Electrical Engineering Trades: Form No. 51.

Shipbuilding Trade: Form No. 52.

Wrought-Iron and Steel Tubes Trade: Form No. 57.

Non-Ferrous Metals Trades (Smelting, Rolling and Casting): Form No. 60.

Finished Brass Trade: Form No. 61.

Recent Developments in Cast Iron

(*Concluded from page* 190.)

that cast iron was a most satisfactory material to use for many structural purposes. Quite recently in Germany he had seen a large crankshaft twelve feet long made of cast iron, and that was only the beginning. If one took the work which had been done on creep and on fatigue, it would show that it was the dray-horse class of material which was showing up particularly well as against the race-horse type. If cast iron was going to be used for crankshafts, why should the foundries not get hold of these improvements and use them? These improvements were being made all along the line, and he thought if the foundry industry did its best to meet inquiries day by day, that it would do much towards capturing the trade. These developments were not being used as much as they ought to be, but one had to be very patient. It was sometimes pathetic to see people think they could get good prices for material by just putting a penny in the slot.

In reply to Mr. Wright, Mr. Pearce said he had never found the effect of sulphur very serious. He believed that sulphur existed in its least harmful form as manganese sulphide, and that the right amount of manganese was about 1.7 times the sulphur plus 0.3, plus the loss by oxidation. If manganese was increased one reached the optimum point where the sulphur was eliminated, but by further increases the metal began to harden again because the manganese began to exist as manganese carbide. Nevertheless manganese could be increased to a large extent before such an effect was produced. In any case there would probably always be some proportion of iron sulphide present. He did not think he wished to suggest that inclusions were advantageous. These fine structures were from irons which did not have any inclusions at all, or where the inclusions were rendered inocuous. He thought coarse graphite was good for wear and fine graphite was bad for corrosion. With regard to soda ash, that might have a good effect as a scavenger of the metal quite apart from any sulphur reduction. There were probably other conditions also, but he had not yet been able to enter into those.

Replying to a further question as to whether copper in excess of 3 per cent. would not have the same effect as titanium, Mr. Pearce said it would in the absence of silicon.

Recent Developments in Cast Iron

THE NEW TITANIUM IRONS

In his opening remarks, when lecturing before the Staffordshire Iron and Steel Institute last week, Mr. J. G. Pearce (director of the British Cast Iron Research Association) pointed out that cast iron consisted of an alloy of iron and carbon, having a melting point which permitted casting to be carried out from a shaft type of furnace —the cupola, and cast into sand moulds. If those iron-carbon alloys containing as much as four per cent. of carbon were melted and cast, a very hard, white and brittle material was produced which was of little industrial value. Combined with silicon these alloys formed a series with the carbon partly in the combined and partly in the graphitic condition. Cast iron contained more silicon, sulphur and phosphorus than steel. In what might be described as the pre-war foundry era, founders made castings in cast iron from pig-iron and scrap, using silicon as a graphitising element to soften the carbide and to form graphite, which was a machinable material. The structure of that material was mainly ferrite and pearlite.

The main change in the material over the last ten years lay in the fact that the pearlitic structure occupied the whole area, and instead of having a tensile strength of eight to ten tons per sq. in., as with ordinary cast iron, the modern type of iron had a strength double this figure, and a structure comparable with eutectoid steel. These improvements had been made during the last ten or fifteen years. Improvements had been made by the free use and alloying of such elements as nickel, molybdenum, chromium and copper with the iron. Nickel, instead of embrittling the matrix like silicon, tended to toughen it, and copper, which was now being studied, in some respects had the same effect as nickel.

Inoculated Irons

If one referred to the British Standard Specification No. 321 it would be found that the tensile strength was stated as nine to eleven tons per sq. in. That represented the pre-war specification, but to-day the common quality of iron had a tensile strength of from fifteen to eighteen tons per sq. in. By going further with the manipulation of carbon and silicon, by taking care to use the exact quantities required, it was possible to go higher than eighteen to twenty tons per sq. in., and that was by no means uncommon. There was, however, a risk of the material going white.

The introduction of these improvements was commenced a few years ago by introducing into the ladle a graphitiser, which was termed an inoculant. These inoculants took the form of calcium silicide, or ferro-silicon with nickel, and the strongest irons in this country were now made in this way, and thirty tons in tensile could be obtained. An iron of 2.7 per cent. carbon, 2.7 per cent. silicon, 0.15 per cent. phosphorus, with 1.0 per cent. of nickel and ferro-silicon gave a tensile strength of twenty-eight tons per sq. in., while an iron containing 3.4 per cent. carbon, and 1.8 per cent. of silicon made as a straight iron would only produce between thirteen and fourteen tons per sq. in. This inoculation process produced a short stocky graphite which favoured wear and corrosion resistance.

Superheating

In 1929, it was discovered in Germany that by superheating cast iron, the metal was refined, and the finest possible type of graphite was produced. It was supposed that the ordinary melting methods for cast iron did not succeed in dissolving all the graphite, so that flakes got into the ladle and acted as centres or nuclei. If the superheat was carried to the point where all the nuclei were dissolved the fine structure would be obtained. The efforts to get this fine graphite were only partially successful, and it was not possible to obtain it right through the structure. These mixtures of fine and coarse graphite were very bad, so that in order to eliminate the possibilities of such a mixture, the inoculation process was devised. Strongly inoculated irons produced in their train some foundry difficulties—more refractory sand was required, the molten metal had a shorter "life," and the shrinkage went up considerably, so that steel foundry difficulties were obtained in the iron foundry.

The British Cast Iron Research Association set itself out to try to convert the coarse graphite into the fine graphite structure, and the means by which it had been done was interesting. A little titanium was added to the melt and then carbon-dioxide gas was passed through, the result being that the change took place. This work was being carried out by Dr. Norbury, and it was interesting to note that there was no change when titanium alone was added, but only when the gas was passed through. The resultant material was hard, dense and very strong. It was not easy to obtain this change with cupola-melted material, but it was along those lines that work was now being done.

Non-Metallic Inclusions

Mr. Pearce said he believed that the problem which confronted all metallurgists to-day was the problem of non-metallic inclusions, and he thought it would be found that this problem would have remarkable similarities for the ferrous and the non-ferrous metals. The growth of cast iron due to the penetration of oxide gases down the cavities caused the metal to oxidise to quite a considerable depth. This produced a state of stress which resolved itself into a crack. In order to resist heat, the iron would have to have fine graphite to prevent the ingress of the gases, and it was thought that silicon should be useful. The alloy known as "Silal" was devised with about 6 per cent. of silicon with fairly low carbon, and this produced an iron which was very heat resisting, though it was rather brittle. This brittleness had, however, been overcome by introducing nickel or chromium in those irons known as "Nicro-silal," and nickel and copper in those irons termed "Ni-resist." By putting in enough of these elements it was possible to produce a material without a critical point, and which was three hundred times more resistant to corrosion than cast iron. They were certainly rather expensive, but where it was justified they had done very well.

Pig-iron was the raw material of the founder, and no country in the world had the resources of pig-iron that was obtained in this country, though he did not think that fact was appreciated sufficiently. It was to the benefit of the industry that there were still furnaces where cold-blast material was produced. They did not know fully why the differences between cold- and hot-blast iron existed, but that differences did exist there was no doubt. Carbon and silicon in the iron were lower for a given fracture than from a hot-blast furnace. The same thing applied to small furnaces which were run slowly and with a semi-cold blast.

DISCUSSION

MR. H. E. COOKSON said he had been very interested in the cycle of operations where carbon-dioxide gas was passed over the iron, and in Mr. Pearce's references to corrosion and to heat-resisting irons. Enormous strides were being made into the subject of cast iron. He had recently an experience about which he would like to ask Mr. Pearce: it concerned a ladle of iron intended for chilled castings, and unfortunately the iron was poured into a wet ladle. There was not a serious explosion, but it caused a bad boil, and the result of the casting operation was to put on about three times as much chill, though there was little chemical change in the iron itself. It would be interesting if Mr. Pearce could offer any comments on that.

Titanium-Treated Irons

MR. W. HOSKISSON referred to the titanium-treated irons, and Mr. Pearce's theory that the good effects were due to the neutralising of slag inclusions, and suggested that that was why cold-blast pig was superior. It was produced in small furnaces, and was given long periods of quiesence in the furnace hearth. With regard to the difference between foundry irons to-day and the pre-war period, he would suggest that a lot of this was due to mass production, as against furnaces producing only five or six hundred tons per week. Irons were now produced at the rate of five hundred tons per day, and were inferior to those produced by the slowly-driven furnaces. To-day it was no uncommon thing to produce thirty or forty tons of pig-iron in a few hours, with no refining period, but years ago there was a definite refining going on in the furnace hearth. It had been good to hear Mr. Pearce praise cold-blast iron, as he had always thought him to be antagonistic. What relation did the work which Mr. Pearce had outlined bear to the total quantity of iron produced? He should think it was very small and he thought they had been discussing questions which were only of theoretical importance to the founder. The founder succeeded remarkably well in producing castings, which were as good or better than those produced by any other country. How far had these special irons been taken up, and how far were they likely to be taken up?

MR. J. T WRIGHT referred to the inoculated irons, and asked what would be the effect of increased cooling on the metal of the same composition, also what would be the effect of delayed cooling, further what would be the effect of sulphur upon the crystal structure of these two metals? Recent work had been done upon the use of sodium carbonate in relation to cast iron in order to rid it of its impurities. Now Mr. Pearce had suggested that these impurities had possible advantages, and he would appreciate some explanation of that.

AUTHOR'S REPLY

MR. J. G. PEARCE, replying, said that with reference to the wet ladle, he would not say positively that the chilling action was due to hydrogen, but he thought that some possible action of steam took place. He could not say actually that it was hydrogen, but he did know that it was due to a gas. He thought Mr. Hoskisson was quite right in suggesting that the quiescence of the cold-blast metal in the hearth allowed the slag to get away. The present position of blast-furnace practice was this—the quality of British pig-iron was less satisfactory because furnaces had become larger, but even with these conditions things had not been pushed so far as they had in America, so that British pig-iron was still better. Cold-blast iron was usually made in a small and slowly run furnace, and was run with a cold blast, which allowed the carbon and silicon to be lower for a similar structure. He did not know why Mr. Hoskisson thought he was antagonistic to cold-blast iron. Mr. Hoskisson's question regarding the relation of special irons to the total produced was a very tall order. He would not like anyone to think he was only interested in these academic questions. He had a very profound belief in the future of cast iron as a structural material, and he did not ask himself what the economics were of this or that development. These improvements, at the lowest computation, would allow a man to put his business beyond the competition of the back street man who knew nothing. The whole of metallurgical research was bringing them back again and again to the remarkable truth

(*Concluded on page* 189.)

Manufacture and Application of Modern Cast Irons

Last Friday, Mr. J. W. Gardom, consulting engineer, of Birmingham, read a very comprehensive Paper before the Manchester Association of Engineers in which he surveyed briefly the complete field of the modern cast iron. In the section devoted to melting, the cupola, air furnace and rotary melters were dealt with *seriatim*. In connection with rotary furnaces it was pointed out that they are now available fired by pulverised fuel, oil or gas. An interesting development in the construction of the Brackelsberg rotary furnace is worthy of mention. It is usually found that a rotary furnace lining wears unevenly, most wear occurring at the burner and where peak flame temperatures are obtained. It has so far proved impossible to patch rotary furnace linings, and this has meant that a furnace has often been relined due to a lining being thin at the burner end, whilst the lining at the gas outlet end is still reasonably thick.

The Brackelsberg furnace barrel is now made symmetrical at both ends, so that if excessive wear occurs at one end the barrel can be lifted out and reversed end for end. This considerably increases lining life.

The principle advantage of the rotary furnace for the production of high-duty irons is the close metallurgical control. Acid linings are employed so that phosphorus and sulphur remain unchanged. Carbon can, however, be controlled within ± 0.05 per cent. through the range 0.3 to 3.5 per cent., and silicon and manganese can be controlled within the same close limits. Further advantages are the high metal temperatures (up to 1,600 deg. C.) and low production costs due to use of cheaper raw materials.

After dealing with both high frequency and rocking arc electric furnaces, a survey was made of the metallurgical control of material, in which the influence of phosphorus on soundness was stressed. The effect of nickel and molybdenum, the latter in tabular form, on cast iron was dealt with.

Moulding and Coremaking

Mr. Gardom's remarks under this heading are reproduced below in full.

Parallel progress has been made in the moulding operations. The moulds are prepared faster and better than before. Here again research and experiment has been necessary in two directions: (1) the method of making the mould; and (2) the materials from which the mould is made.

Method of Making the Mould

The larger quantities commonly called for to-day necessitated the introduction of the moulding machine. Various types of moulding machines have, of course, been used for many years, but it is only within the last few decades that their possibilities have been fully exploited. The following table shows the relative production by hand, plate and machine moulding on the same simple job:—

Hand	12-18 per day.
Plate (hand rammed) ...	40-50 per day.
Machine (power operated)	100 per day.
Machine (correctly serviced)	600 per day.

In addition, the machine-made mould is usually much more accurate than that made by any of the other methods. In common with other industries it has been realised that a great deal of effort (and money) has been wasted in the past in inefficient lay-out of the works, and by needless transport of materials (especially by hand). The up-to-date founder calls the conveyor and elevator to his aid.

Sand Control and Preparation

Increased speed of production as well as the special casting requirements of the new irons called for improvement in the moulding sands. This improvement has been mainly brought about by the routine equipment for foundry sand testing, and hourly determinations of strength, permeability or vent, and moisture are now taken in the most up-to-date foundries. A full description of the apparatus used is given in "Routine Methods of Testing Green Sands."*

The improvement in the type of sand used has been due mainly to the work carried out in the laboratories attached to the more up-to-date foundries. This research work has resulted in a very definite type of moulding sand now becoming common in machine moulding and mechanised foundries.

This new sand has an increased "flowability," a smaller amount but higher quality of clay bond, higher permeability and certainly a higher refractoriness or durability than the type of sand used in old hand-moulding shops. Such a sand has been obtained through a better understanding of the requirements of mechanisation and of the basic qualities of true moulding sand, such as the condition and size of the sand grains and the physical properties of the clay bond.

These new sands may be prepared and maintained from a mixture of natural moulding sands or a mixture of natural moulding sands and silica sand, or from silica sand and independent colloidal clay additions. The last-named type is usually known as synthetic moulding sand and gives, from the nature of the combination, easier control. When this work was being done it was first considered that the ideal moulding sand would consist of even sized grains of silica with easily controlled additions of clay and water to give the necessary bond. This ideal when obtained, however, had to be modified owing to moulding troubles, but such synthetic sands have proved invaluable to the mechanised foundry where continuous treatment of the sand is necessary and where the amount of milling must be cut to a minimum on account of cost.

* "Proceedings," Institute of British Foundrymen, 1932-1933, Vol. 26.

The Mechanised Foundry

During the past 50 years foundry engineering progress has advanced as rapidly as any branch of engineering. The present-day mechanised foundry would not be recognised by the older engineers who only remember the foundry of their apprentice days. The undesirable conditions have been almost entirely removed and it is even difficult at times to find the sand.

The first large-scale mechanised foundries were developed in America, and one such foundry working in this country is the Ford foundry at Dagenham. In this foundry the sand is continuously handled to the moulding machines, the moulds being conveyed on an overhead pendulum type conveyor to the casting station and then through cooling chambers where steam and fumes are extracted. The mould continues its journey to the knock-out position where sand and castings are separated. The sand then passes through a continuous reconditioning process and is returned to the moulding stations. The castings are transferred to another conveyor which carries them outside the building until cold enough to handle and then automatically returns them to the fettling departments. Provision is also made for the automatic return to the cupola stage of the excess metal left in the ladles and the iron borings from the machine shop which after being placed in suitable containers are remelted.

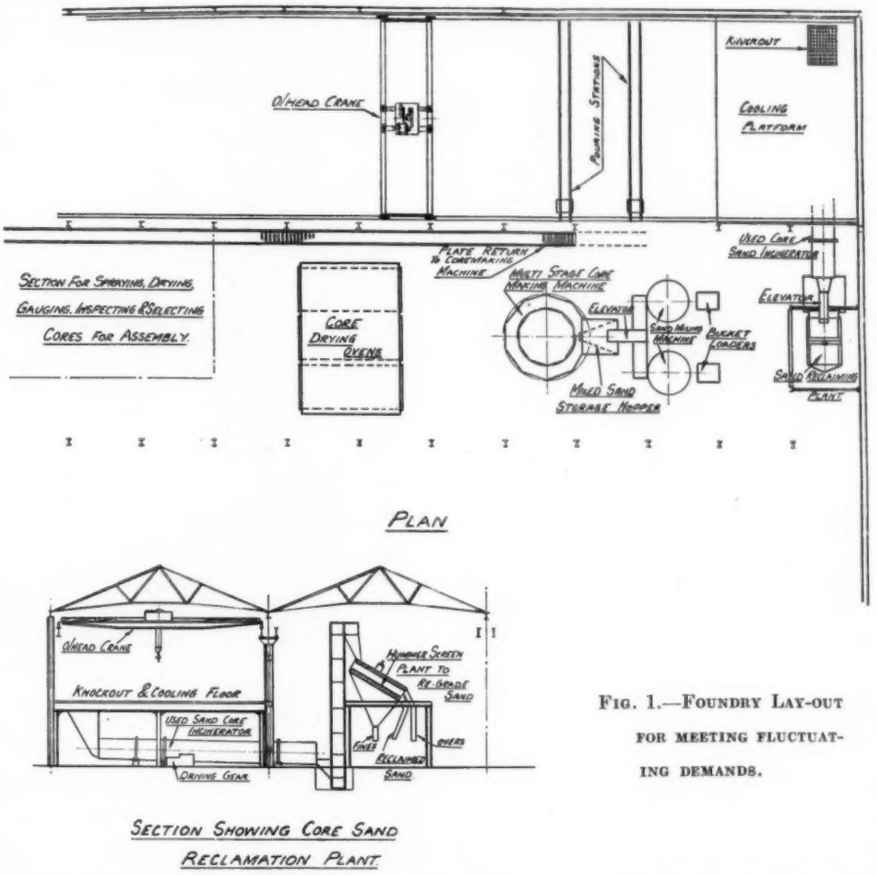

FIG. 1.—FOUNDRY LAY-OUT FOR MEETING FLUCTUATING DEMANDS.

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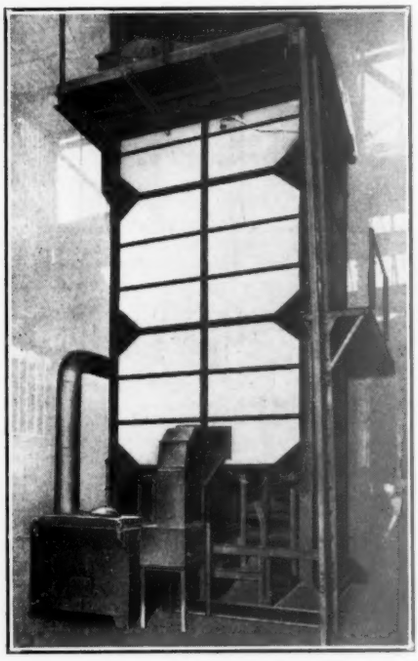
Such lay-outs are not applicable in many cases in this country, and it is to be regretted that the first installations introduced were more concerned in turning us into a little America than providing the most suitable equipment for our conditions.

The problem of the particular requirements of British foundries has recently received the serious attention of a number of workers, and many successful plants are now operating in small units and in partially-mechanised plants. Further, it has been shown that mechanical handling of sand to hand-moulding machines can produce highly-profitable results.

Perhaps the most widely-quoted instance of modern cast iron is the automobile crankshaft, and many articles have been written with illustrations of the fully-mechanised lay-out of the Ford Detroit crankshaft foundry, which is capable of a very large output. In this country also smaller but very efficient lay-outs are possible, and Fig. 1 shows an installation capable of meeting fluctuating demands. It is a complete unit. The sand after special preparation is made into moulds. The moulds are then passed through a continuous stove for drying (Fig. 2)



[Courtesy Bagshawe & Company.

Fig. 2.—Vertical Continuous Core-drying Stove.

and, after casting, the sand is recovered by treatment in a special continuous incinerator (Fig. 3) and is then ready for re-use.

The greatest problem in connection with mechanised foundries to-day is to find suitable executives to manage them. Even with correctly-designed plant, constant and continuous attention to detail and elimination of waste movement is necessary. The foundryman's training seems to be unsuited for supplying the best men, perhaps because he is too much of an artist. The writer is of the opinion that an engineering training would probably be more suitable for men taking over the management of a fully-mechanised foundry.

Modern High-Test Irons

It has been stated already that the quality of the cast iron available to the engineer to-day is far superior to that available in the past. A few years ago cast iron was regarded as a relatively cheap and brittle material of use only in situations where its weight, rigidity or wear-resisting properties were of value. In 1928 the B.E.S.A., which has since become the British Standard Institution, drew up a specification for General Grey-Iron Castings (B.S.S. 321/1928), in which there were two grades, A and C. In grade A material a tensile strength of 12 tons per sq. in. was called for, and in grade C 10 tons per sq. in. At the time this specification was drawn up, 12 tons per sq. in. was a good average figure for the strength of engineering castings, but to-day 15 tons per sq. in. is obtained quite regularly and irons produced by special processes can be obtained with strengths well over 20 tons per sq. in.

The modern foundry is able to offer the engineer cast irons suitable for any particular set of service conditions, but it is all too common to find that the drawing office and machine shop demand one type of iron where the actual conditions under which the casting has to serve demands another. In the case of the automobile cylinder block, the two essential properties that the engineer demands in these castings are easy machining and a metal that will be sound in the most complicated design, *i.e.*, one in which thick and thin sections are placed adjacent to one another. This seriously limits the founder in

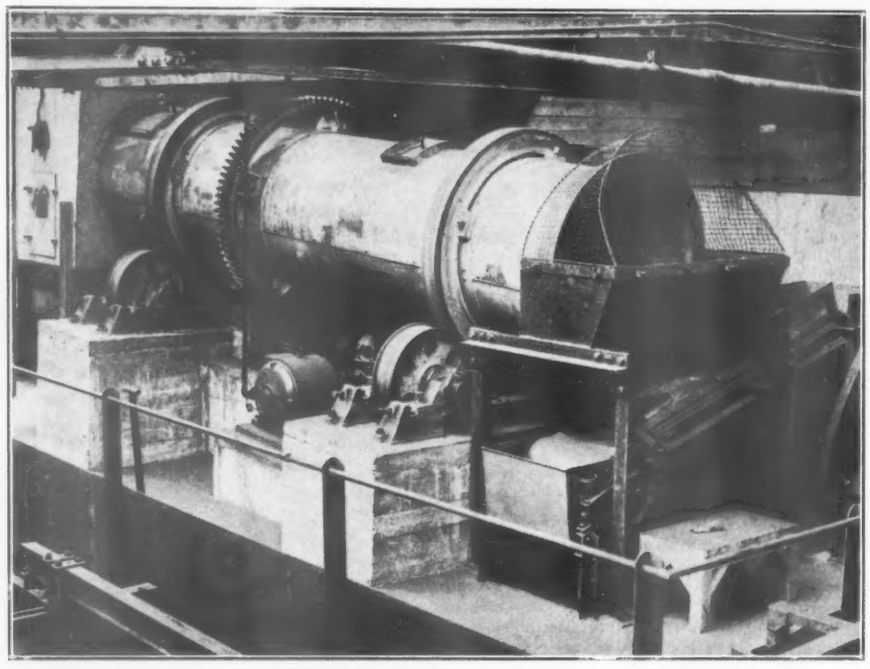


Fig. 3.—Continuous Incinerator for the Reclamation of Core Sands.

producing a casting which will have good wear-resisting properties, and wear on cylinder walls is rapidly becoming a serious problem. A great amount of investigation work has been carried out by metallurgists on this subject, and recently it has been suggested that the action is mainly one of corrosion caused by the acids and moisture produced in the combustion of motor spirit. Where the problem is one of wear or corrosion, suitable irons are available for resisting either or both of these conditions. This is a clear case where, if the designer, engineer and founder could co-operate, great improvements could be effected.

One of the outstanding properties of cast iron is its resistance to wear and abrasion, but the engineer does not appear to realise that free-cutting machinability and the best resistance to wear do not go together. The more recently developed special cast irons can be sub-divided roughly as follow: High-strength irons, fatigue-resistant cast irons, wear- and abrasion-resistant irons, and heat- and corrosion-resistant irons.

High Strength Irons

As has already been pointed out, the modern tendency has been to produce higher strengths by reducing to a minimum the elements which have a weakening effect. By this means it is possible without the use of alloy additions to obtain cast irons with strengths of up to 18 tons per sq. in. By the addition of a small amount of nickel or nickel and chromium to a suitable iron, it is possible to obtain strengths of up to 20 tons per sq. in. Two types of iron, one alloyed and the other unalloyed, are now available in which castings may be produced with strengths of 25 tons per sq. in. and over in the as-cast condition, and even higher after heat-treatment. One of these irons, which contains nickel, is called Nitensyl, and the other is known as Meehanite. The latter was first developed in America, but is now being made by several firms in this country, and has markedly superior properties to ordinary cast iron. It is made in several grades, but the high-strength material is close grained and tough and has exceptional resistance to shock and fatigue. There are undoubtedly numerous applications where such an iron can be of great benefit to the engineer. It is already being used for dies for metal pressing, brake drums, cam and crankshafts, crusher jaws and frames. Nitensyl also is being produced by a number of foundries and has been used in numerous applications where high strength and toughness are required.

Fatigue Resistance

It has been discovered only recently that cast iron possesses excellent fatigue-resisting properties, and there are signs that in the near future it may supersede forged steel in many applications where alternating stresses are to be resisted. Many metallurgists are of the opinion that cast irons of the type described above are capable of being used—possibly after heat-treatment—for cam and crankshafts for internal-combustion engines. The benefits of molybdenum as an alloy addition in cast irons to resist fatigue and shock have recently been studied and small additions of this element have been found to give improved properties.

Wear and Abrasion Resistance

At one time, if a high abrasion-resistant cast iron was required it was usual to obtain either a white or chilled iron. Such an iron had a Brinell hardness number of approximately 500, and although hard, did, under certain condi-

tions, wear fairly rapidly. It has been found, however, that by the use of nickel a white or chilled iron can now be obtained with a Brinell number of up to 800. These irons are known under the trade name of Ni-hard. Similarly when a wear-resistant iron was required a grey iron with a Brinell of 200/230 was obtained, but it is now possible to produce air-hardening irons which harden on cooling from the molten state to give a Brinell hardness of about 400. A similar hardness may be obtained in softer irons after a simple heat-treatment, and such irons possess the advantage that they are fairly easily machinable in the as-cast state. Mention should also be made of the new nitrogen-hardened iron, which has a hardness on the treated face of approximately 1,000 Brinell. These irons are all in general use in such applications as gears, cylinder liners, dies for drop-stamping and hot pressing, machine-tool parts, etc. It can be said that the various types can meet any condition of wear and abrasion more successfully and cheaply than any other ferrous material.

Heat and Corrosion Resistance

Improved heat resistance has been obtained by the use of a small amount of chromium and a new iron has been developed by the British Cast Iron Research Association, known as Silal, which is giving good service for firebars, furnace parts, etc. This iron is purely for heat resistance and has little or no increased resistance to corrosion. A new type of iron, which has made rapid progress during the past few years, is the austenitic cast iron known as Nimol or Ni-resist. This iron contains a fairly large amount of nickel and copper and also chromium, and is consequently fairly expensive. It has, however, excellent corrosion and heat-resistance properties and is now being used in such applications as valves for corrosive and erosive liquids, such as mine water and liquids containing solid matter in suspension, salt baths and dies for gravity die-casting of non-ferrous metal, etc. Another austenitic cast iron is known as Nicrosilal, developed by the British Cast Iron Research Association, and this has also good corrosion resistance and excellent heat resistance. The first austenitic cast iron to be developed was Nomag, which was invented by Mr. S. E. Dawson at Ferranti's. This iron, which contains a fairly large percentage of manganese, is used for its non-magnetic properties.

Reviewing the previous paragraphs on the properties of the irons available—high-strength irons, fatigue resisting, wear and abrasion resisting, heat and corrosion resisting—it is very obvious that all the properties for an efficient internal-combustion engine, or steam engine or turbine, or electric motor, can be obtained in the "as-cast" condition, or cast and modified by suitable heat-treatment. The consequent economies will be immediately obvious to the designer or engineer.

Contrast for example, the number of operations required to produce a steel forging, and those required to produce a casting. For the forging, an ingot has first to be cast, a portion of which is rejected due to piping. This ingot then has to be heated in soaking pits and rolled into suitable bars or billets. The billets are again heated to a temperature suitable for forging, and the forging operations may be numerous depending on the intricacy of the forging required. With a casting, the molten metal can be cast to much closer tolerances in one operation.

It is recommended, as an aid to the utilisation of these irons, that the engineering hand books and pocket books should be brought up to date, and instead of cast iron being mentioned as having a tensile strength of from 9 to 11 tons, all the various physical properties and the numerous types of modern irons should be suitably tabulated and made available to the engineering design office.

The Moulding of a Three-Ton L.P. Marine Cylinder*

By V. Braby.

The first consideration in moulding any large job of considerable weight and bulk is the most economical way and method to produce sound castings. Because it is very seldom that a repeat order is required off the same pattern, it is best to make the pattern and coreboxes as cheaply as possible. It is advisable to make a skeleton pattern, as considerable time and money would be wasted in making a full pattern, which after use would most likely be put away and forgotten.

After deciding upon all the fundamental points, the next consideration is the way the mould shall be made. In this case the open end of the cylinder was moulded down, a spindle of about 3 in. dia. was erected on a base plate and a board provided on which, by means of the spindle, a seating was struck, to enable the pattern to be placed over the spindle and be on the seating provided, thus ensuring complete alignment of the pattern. A rough semi-top was then cast in the form of a grid, the object being to enable the part between the top of the cylinder and the feet to be lifted away.

The base plate and grid are joined by sides of roughly the following dimensions:—Length about the depth of the cylinder; width about 8 or 9 in., with a flange on each end to enable them to be bolted to the top and bottom plates, thus forming a rough frame box. This box was so made that when the mould was finished it would part at each diagonal corner, thus enabling the sides to be taken away. In order that the exhaust and draincocks may be easily withdrawn some of the draincocks on this casting were set at an angle. The mould was backed by a layer of loam, succeeded by bricks built out flush with the sides, the remaining sides being built up in the same fashion.

The top closing box was of the ordinary moulding-box type with bars running across. The depth of the box was about 4 in. Eight runners were used of about $\frac{3}{4}$ in. dia., and three risers $1\frac{3}{4}$ in. dia. were taken off the feet of the cylinder. The runners were arranged around the top, so that when the metal was poured in, it dropped straight down between the cylinder walls. Where the spindle protruded, the mould top was left clear for the purpose of allowing the gases to escape with ease from the main centre core. When this was completed the top was marked and removed, the sides and pattern were taken away, leaving only the spindle. The main purpose of the spindle is now seen, for a loam-board was made, which when in position on the spindle struck up the centre core.

In this case the brickwork was made first, leaving a space of about 1 in. from the face of the loam-board to the face of the brickwork, which was afterwards made up with loam. The diameter of the core was about 40 in. The brickwork was about 9 in. The remainder was left open for the purpose of filling up with a perforated tube, around which were packed ashes, thus enabling all gases to escape freely. The space between the loam-board and brickwork was then finished off, after which the spindle and board were removed. The whole job was then bodily removed to the stove to undergo a thorough drying of about three days. After the second day the mould was taken out and blacked, as also were all the cores which had been made in the meantime, and together they were returned to the stove for a further day's drying. The mould and cores were assembled, the mould then being closed and made ready for casting.

Bolts and clamps were used to secure the parts of the mould together, very few weights being required. The metal entered the mould through a large "well gate" into a channel large enough to supply all the runners, thus ensuring a steady flow of clean metal. About 3 to 4 cwts. of metal was run through the job to ensure a clean casting. The waste metal came through the risers into pig moulds which had been previously dug.

* Prize entry submitted to the Wales and Monmouth Branch of the Institute of British Foundrymen in a Short Paper Competition.

Properties of 18-8

Discussing experiments on corrosion-resisting chrome-nickel steel at various temperatures in a Paper in the "Transactions" of the American Society of Mechanical Engineers, H. C. Cross observes that in high-alloy chrome-nickel steel precipitates are obtained within certain temperature ranges which are partly due to the C content and which adversely affect the properties of the steel. Thus, from 500 deg. the corrosion resistance diminishes, as well as the usual physical properties, the material becoming more brittle. The 18-8 steel is therefore only of limited use at high temperatures, and for temperatures above 500 deg. it is advisable to use steels containing at least 20 per cent. Ni. The author's experiments have also attempted to elucidate the differences in tensile strength, creep and fatigue of cast and rolled 18-8 Cr-Ni steel with high and low carbon values, viz., 0.067 and 0.125 per cent. C, measurements being conducted at various temperatures up to 680 deg. He found that the tensile strength of the cast specimen at room temperature was 30 per cent. lower than that of the rolled specimen with the same C content, while at 480 deg. the strength of the 0.067 per cent. C steel diminished more rapidly than that of the 0.125 per cent. C steel. Fatigue-bending tests showed that in the cast steel the most excessive variations in load did not suffice to enable the fatigue limit to be accurately determined. Under a continuous load uniform elongation is only reached after 500 hrs., the rolled specimens with higher C content giving better results than those with low C content at temperatures of 540, 595 and 680 deg. Water-quenched specimens on the whole showed a more marked creep than the air-cooled ones. Grain size in the cast specimens was, as expected, of marked influence on the physical and mechanical properties. The magnetic permeability in the creep experiments was found to increase with both the temperature and the load, while notched-bar tests gave a higher value with water-quenched low- and high-carbon rolled specimens than with the corresponding cast specimens. Examination under the microscope confirmed the precipitation of carbide at high temperatures, time and carbon content being of marked influence on the degree of precipitation. With the rolled specimens the most marked precipitation of carbide was observed at the grain boundaries and in the cast specimens at the original ferritic surfaces.

Technical Advances in Refractories

Mr. W. J. Rees, in the course of a Paper read before the Birmingham and Midland Section of the Society of Chemical Industry and the Refractories Association, pointed out that the constitution of clays had been studied by colloid chemists, as well as by mineralogists and ceramic technologists. By coupling chemical analyses and crystallographic measurements with X-ray diffraction patterns it was possible logically to deduce the main structural features of this group of minerals. The application of similar technique had led to the elucidation of changes that took place when fireclays were raised to a high temperature. Studies of the changes in crystalline form which took place when crystalline silica was heated had led to definite improvement in the durability of silica refractories.

Vitreous Enamelling Section

DEALING WITH PAPERS PRESENTED TO THE INSTITUTE OF VITREOUS ENAMELLERS

The Use of Town Gas for Vitreous Enamelling*

By W. DIETERICHS and P. LLOYD

To discuss the application of fuels for industrial processes requires detailed knowledge, not only of the fuels available, but also of the operations to which they are to be applied, and in the latter department especially the authors of the present Paper are very conscious of the inadequacy of their experience.

In considering the general aspects of the subject, it becomes evident at once that there is a dual bond of interest between the enamelling industry and that which the authors represent, for the gas industry is not only a potential supplier of fuel to the vitreous-enamelling industry, it is also the purchaser of a great bulk of vitreous-enamelled ware, largely in the form of gas cookers, but also as flue material, lighting fittings, etc.

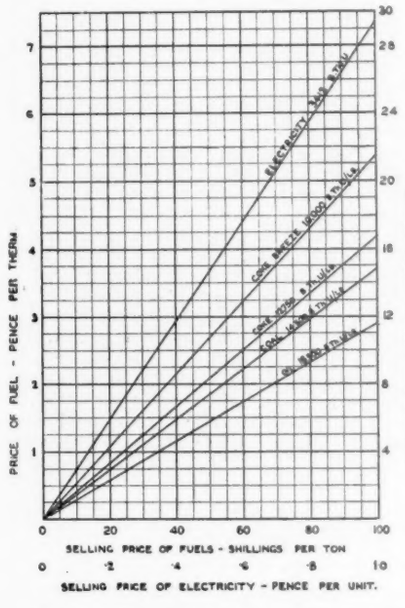

PRICE OF FUEL - PENCE PER THERM
PRICE OF ELECTRICITY - PENCE PER THERM.
SELLING PRICE OF FUELS - SHILLINGS PER TON
SELLING PRICE OF ELECTRICITY - PENCE PER UNIT.

FIG. 1.—RELATIONSHIP BETWEEN PRICES PER TON, CALORIFIC VALUE AND PRICE PER THERM OF RAW FUELS.

The increase that has taken place in recent years in the sale of enamelled gas appliances is well known, and it will be realised that many companies, like the Gas Light & Coke Company, are now purchasing no cookers except with a vitreous-enamelled finish. One may, nevertheless, be interested in the following figures, which illustrate the growth in the number of vitreous-enamelled cookers installed during recent years. They refer to the Gas Light & Coke Company alone, and it will be readily appreciated that the figures for the country as a whole are of quite a different order of magnitude.

Number of Vitreous Enamelled Cookers Issued Per Annum

	Total.
1933	30,000
1934	45,098
1935	176,058

A point which is also worth mentioning is that other vitreous-enamelled products, such as kitchen ware and baths, are closely associated with the use of gas and coke as fuels.

Fuel Requirements

As a supplier of fuels, the gas industry offers two commodities, coke as a low-priced smokeless fuel, and gas as a highly-refined fluid fuel; but before considering the properties of these and of the alternative fuel in detail, the fuel requirements of the vitreous-enamelling industry should be appreciated. There are, in the main, three operations requiring heat:—(1) Frit melting; (2) drying; and (3) fusing the enamel. The theoretical heat requirements for these three processes may be roughly estimated as follow:—

Frit Melting.—850 B.T.U. per lb. of frit, 137 B.T.U. per sq. ft. of enamelled surface (two coats), assuming 0.06 lb. per sq. ft. for the grip coat and 0.1 lb. per sq. ft. for the colour coat.

Drying.—120 B.T.U. per sq. ft. of enamelled surface (one coat), assuming 0.25 lb. enamel per sq. ft.

Fusing the Enamel.—185 B.T.U. per lb. on cast iron; 800 B.T.U. per sq. ft. of enamel (two coats on 18-gauge metal).

In the first process the heat is required to melt the glass, and the theoretical heat requirement has therefore been taken as the total heat above 60 deg. Fah. of a typical batch at the pouring temperature. In the second process the heat is necessary to evaporate the water from the applied coating, and the theoretical heat requirements have been taken as the heat necessary to evaporate the water. It is true that the evaporation of the water is not accomplished without heating the iron to the temperature of the drier, and the sensible heat of the metal might have been included in this estimate; it has been omitted for reasons of expediency. In the fusing operation, theoretical heat requirements have been taken as the total heat in the useful load above room temperature. Anticipating the results given in the latter part of this Paper, it may be mentioned that the gross heat units required in practice to carry out these three operations are of the following order of magnitude:—

(1) *Frit Melting.*—5,000 B.T.U. per lb. of frit, equivalent to about 800 B.T.U. per sq. ft. (two coats).

(2) *Drying.*—65 B.T.U. per lb. of cast iron, equivalent to about 400 B.T.U. per sq. ft. of enamelled surface.

(3) *Fusing.*—920 B.T.U. per lb. (cast iron); 8,000 B.T.U. per sq. ft. (sheet iron, two coats).

The corresponding thermal efficiencies are therefore:—(1) *Frit melting*, 17 per cent.; (2) *Drying*, 30 per cent.; and (3) *Fusing*, 10 to 20 per cent.

Frit Firing

Frit firing is shown to be a highly inefficient operation, and it might appear at first sight that furnaces could easily be designed to give much better utilisation of heat. A consideration of the process reveals, however, that the problem is by no means an easy one. The main source of heat loss in the process is the flue, and with any normal operation the sensible heat in the flue gases would be recoverable by the use of some recuperative or regenerative system. In this case no such recovery is possible by normal means, since the hot waste gases carry forward small particles of enamel which would very soon put any recuperator out of action. This same difficulty has, of course, been overcome in the case of glass furnaces, and a similar solution may perhaps be found for frit melting.

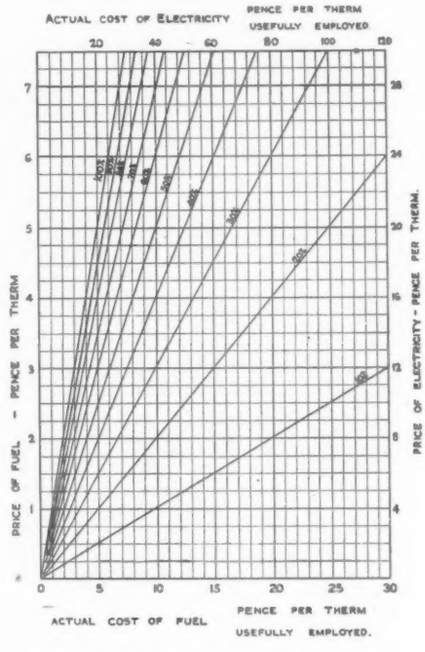

ACTUAL COST OF ELECTRICITY PENCE PER THERM USEFULLY EMPLOYED
PRICE OF FUEL - PENCE PER THERM
PRICE OF ELECTRICITY - PENCE PER THERM.
ACTUAL COST OF FUEL PENCE PER THERM USEFULLY EMPLOYED.

FIG. 2.—RELATIONSHIP BETWEEN PRICE PER THERM, THERMAL EFFICIENCY AND COST PER THERM USEFULLY EMPLOYED.

The drying operation offers no great difficulties, and does not use any very great quantity of heat; and, in any case, much enamelled ware is air dried; but it may be pointed out that it is an operation demanding a flexible, easily-controlled fuel, and, in fact, town gas is being very extensively used for the purpose.

The firing operation is not only that consuming the greatest proportion of fuel, and therefore the most interesting to the gas industry, but is also the most difficult, and consequently the most interesting, from the enameller's point of view. The efficiency obtained in practice is not unreasonable, especially when it is borne in mind that this is a "net" figure, taking no account of the perritts, which may easily treble

* A Paper read before The Institute of Vitreous Enamellers in London, Mr. B. B. Kent presiding. The authors are associated with the Research Department of the Gas Light & Coke Company.

the effective weight of the load. There is no doubt, however, that these figures can be, and will be, improved upon, and it is hoped that town gas will play an important part in effecting this improvement. It seems that present practice in the enamelling industry already demands rigorous control of temperature and of furnace atmosphere, and it may be anticipated that in this process, as in so many others, the precision required in the control of the furnace will tend to increase. If this happens, the result will be to place a premium on the fluid and easily-controlled fuels.

Available Fuels

Turning now to a review of the available fuels, we shall have to include the following:—Coal, coke, oil, town gas, and electricity. Some of refined fuels, such as town gas or electricity, which must be included, although it is not, strictly speaking, a fuel. One reason why the more expensive fuels are able to compete successfully with the cheaper ones for operations of this kind is that they enable higher thermal efficiencies to be obtained. Electricity, for instance, starts off with the advantage that flue losses are eliminated. Town gas comes next on the list, since it enables heat application to be localised as required, and it gives much closer control over the combustion process than any other fuel. Fuel oil may show a somewhat higher thermal efficiency than that obtained with solid fuels, on account of the greater ease of application, and may be ranked as occupying an intermediate position between solid fuels and the highly-refined fuels, gas and electricity. In of storage and ash removal, and a minimum of supervision.

When it is considered that the vitreous enamelling industry is producing relatively high-priced commodities, and that the fuel costs are, after all, small in comparison with other production costs, it will be appreciated that such factors as those mentioned above are of more than theoretical interest.

Town Gas as Fuel

Town gas is relatively a newcomer to the field of vitreous enamelling, and the authors would like to congratulate the furnace makers on the pioneer work they have done in applying town gas to the process. At the same time, everyone will agree that a vast amount of further work will be necessary before the best possible results

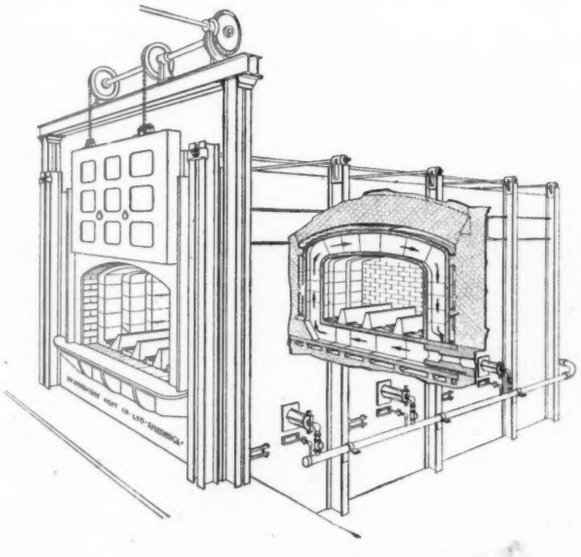


Fig. 3.—Gas-fired Furnace for Vitreous Enamelling.

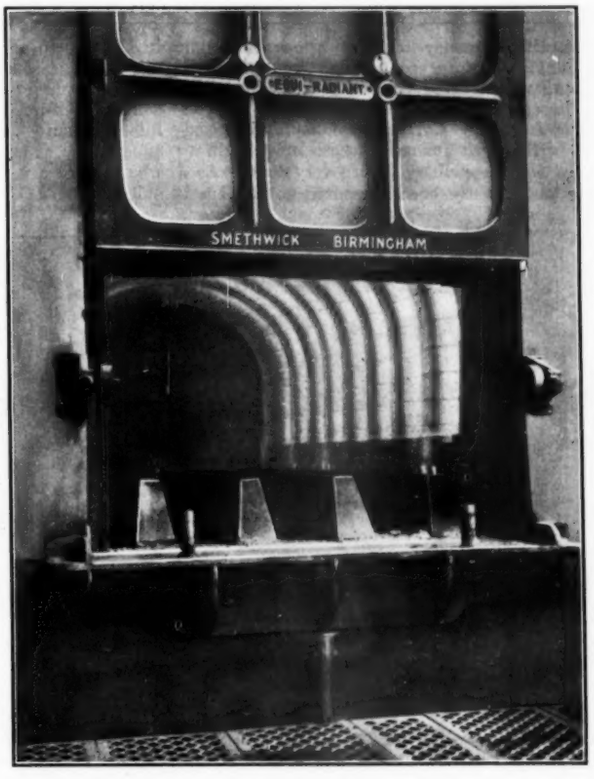


Fig. 4.—Close-up View of the Interior of the Muffle detailed in Fig. 1, showing arrangement of the Tubular Elements.

of the salient properties of these fuels are indicated in Table I.

The relationship between prices per ton, calorific value and price per therm of raw fuel is further illustrated by Fig. 1, which shows price per ton plotted against price per therm for a number of fuels of characteristic calorific value.

Table I.—*Relative Cost of Various Fuels.*

	Approx. price per ton.	Mean calorific value. B.T.U. per lb.	Price per therm (pence).	Per cent. sulphur by wt.
Coal ..	25s.	14,000	0.95	1.4
Coke ..	30s.	13,000	1.25	1.4
Fuel oil (heavy grade)	80s.	19,000	2.3	1.7
Town gas ..	1s. 8d. per 1,000 cub. ft.	500 B.T.U. per cub. ft.	4.0	0.1
Electricity	½d. unit	—	14.6	—

Relative Costs

It appears that, at current prices, there is a very wide divergence between the price per therm of the crude fuels, such as coal, and that considering fuel costs, it must always be the cost of the therm usefully employed that is taken as the criterion, and not the price of the raw fuel. The calculation of this quantity is illustrated by the graph, Fig. 2, which relates the three quantities, price per therm, thermal efficiency, and cost per therm usefully employed. A manufacturer, however, is not concerned with the thermal efficiency alone, but rather with the overall "manufacturing efficiency," which involves such important factors as the following:—Quality of product; percentage of rejects; continuity of operation (time lost in breakdowns, repairs, etc.); maintenance cost of furnace; cost of stoking and supervision; cost of storage of fuel; and cost of ash removal.

All these factors must be allowed for in calculating the overall fuel costs, and it is clear that they must not only tend to react in favour of the higher-grade fuels, but may also outweigh considerable differences in the cost of the fuel per therm usefully employed. In the case of town gas, for instance, the advantages may be summarised as follow:—(1) Unvarying quality of fuel supplied; (2) reliability of supply and operation; (3) low sulphur content; (4) ease of operation under negative pressure resulting in the minimum vitiation of furnace atmosphere; (5) long life of refractories; and (6) the absence are obtained. To do this it will be necessary, not only to design furnaces to make full use of all the qualities of the fuel, but also to take full advantage of all the best available materials, whether ceramic or metallic in nature. Special importance must be attached to this question of materials, and this may have a decisive effect on the technique of gas firing for this process.

A question of some importance in this connection is the possibility of using inflame furnaces for the fusing of enamels. The authors are well aware that the present tendency in the industry would seem to be towards the exclusive use of muffle furnaces, with ample ventilation of the muffle, and they feel a certain diffidence in raising the question at all, but the published evidence on the subject, most of which is of American origin, does not seem to provide sufficient basis for the absolute rejection of this possibility. So many cases have been experienced in other industries where the use of muffle furnaces was held to be essential until the use of town gas came to be investigated, that a thorough examination of this aspect of the problem would seem to be justified. It will be realised that the possibility of using oven-type furnaces is especially important on account of the much greater thermal efficiency which can be obtained by their means. It would be extremely interesting to hear the views of vitreous

enamellers on this subject and to learn from them which constituents of the furnace gases have been found in practice to exert objectionable influence on the enamelled surface, or, alternatively, what percentage of oxygen is considered essential in the muffle atmosphere.

The logical development of vitreous enamelling furnaces would seem to be in the direction of continuous operation, since this not only increases the efficiency of heat application, but also enables a closer control of temperature to be obtained. It may be anticipated, therefore, that in spite of the known objection to continuous furnaces, *e.g.*, lack of flexibility compared with batch furnaces, these may begin to be used in this country before very long. As a Paper has recently been presented to the Institute on this very subject by Mr. W. Marshall, of the Ferro-Enamelling Company, there is no need to dilate on the possibilities of this development.

TABLE II.—*Operating Data from a Gas-fired Muffle.*

Process.	Temp., deg. C.	Throughput. Lbs. per hr.	Gas consumption (500 C.V.). Cub. ft. per hr.	Cub. ft. per sq. ft.	Cub. ft. per lb. net.	Cub. ft. per lb. gross.
Fusing colour on sheet iron (flat loads) (average of 4 runs)	800	2,830	3,580	7.49	3.71	1.26
Fusing grip on sheet iron (flat loads) (average of 2 runs)	875	2,135	3,410	9.46	4.75	1.6

Present Practice

Before the description of any actual installations, a brief reference may perhaps be made to some aspects of the technique of gas firing as applied to furnace work. It is universally realised that the temperatures required for enamel fusing are very readily obtainable with town gas without the use of any forced-air supply, and the elimination of the fan and motor for supplying the air blast has various advantages besides the primary one of simplification. For one thing, the operation of the furnace on natural draft ensures the production of a slight negative pressure in the flue system, so that the chance of contamination of the muffle atmosphere is very much reduced, for another, the soft luminous or semi-luminous flame is at a lower temperature than the air-blast flame and consequently imposes less strain on the refractories. Various systems have been devised by the furnace makers for the application of this type of flame to vitreous-enamelling furnaces.

Another branch of gas-firing technique which has recently shown some development is the automatic control of temperature. This may now be carried out with an accuracy equal to ±1 per cent. of the scale-reading of the instrument used for measurement, and no supervision is required, apart from the original setting of the temperature control. The usual method of obtaining this control is to use a thermo-electric pyrometer system arranged with a relay mechanism in such a way that the position of the galvanometer pointer on the scale governs the opening and closing of a valve in the gas line. It may also be made to control a damper in the flue so as to govern the flue-gas composition. An essential point in connection with these automatic controls, as well as with hand-controlled furnaces, is the regulation of the inlet pressure to the control valves. This is effected by some form of pressure governor, of which there are many on the market, and which will maintain the gas pressure constant.

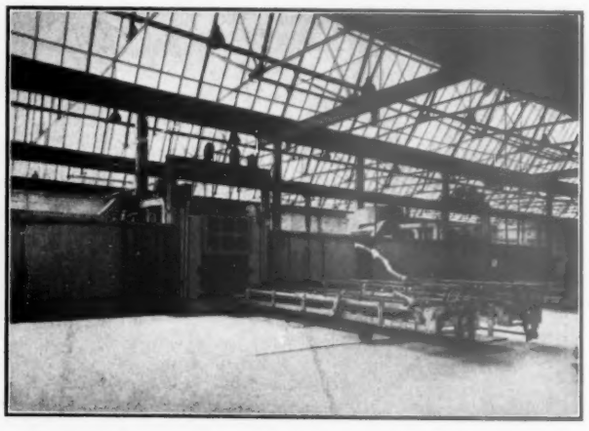


FIG. 5.—GAS-FIRED ENAMELLING MUFFLE INSTALLATION IN A LONDON WORKS.

FIG. 6.—A SECOND LONDON INSTALLATION.

The construction of a typical gas-fired enamelling furnace—the Incandescent Heat Company's Equi-Radiant furnace—is illustrated by the prospective drawing shown in Fig. 3, which shows the passage of the hot gases from the burner through the flue system surrounding the muffle. From this point they pass into a recuperator situated below the furnace hearth, and out to a main flue at the back. This furnace operates with low-pressure gas and natural draft only, so that a slight negative pressure is obtained in the flue system.

Fig. 4 shows a close-up view of the muffle interior, which further illustrates the arrangements of the tubular elements, and Figs. 5 and 6 show actual installations of these furnaces in London factories.

Test Results

In connection with this Paper, an effort has been made to obtain test results on a number of typical installations using a variety of fuels, and a considerable number of tests have been carried out. It must be admitted, however, at the start, that great difficulty has been experienced in obtaining results in comparable form. One difficulty is that the working efficiency of the furnace obviously depends on the rate of throughput, which is not easily standardised, except for a short period, and a test over a short period is, of course, valueless owing to the intermittent nature of the operation. Perhaps the most awkward problem concerns the methods of expressing the results obtained. Clearly, the heat in the load would be most easily expressed in terms of the gross weight of the charge, that is to say, the weight of the load plus perritts, but this takes no account of the fact that in continuous operation the perritts are necessarily warm at the time of entering the furnace.

The effective output, especially on sheet metal, would seem to be more logically measured in terms of the area enamelled, but this method does not enable any allowance to be made for the weight of the perritts. By way of compromise, it has been found necessary to express results on sheet-metal work in three different ways, in fuel consumption per sq. ft. enamelled, fuel consumption per lb. net, and fuel consumption per lb. gross. In dealing with castings, the results have been expressed in terms of the weight basis alone. Among the other variables which are bound to affect the results, and for which no proper compensation can be made, are the firing temperature, the firing time, and the shape factor which governs the quantity of material inserted in a given charge.

Another fundamental problem in connection with the testing of these furnaces is the question whether to take aggregate production figures and fuel consumption figures over an extended period (a week, a month or a quarter) and so to obtain figures based on normal production, or to carry out spot tests on periods of 4 to 8 hrs. The latter method has the advantage of enabling the results to be more fully dissected, but it is open to the objection, previously mentioned, that the results are unduly influenced by the rate of throughput. It is unfortunate but inevitable that the results obtained are not on a uniform basis, since the figures for oil and gas were taken

TABLE III.—*Operating Data on Smaller Gas-fired Muffle.*

Process.	Temp., deg. C.	Throughput. Lbs. per hr.	Gas consumption (500 C.V.). Cub. ft. per hr.	Cub. ft. per sq. ft.	Cub. ft. per lb. net.	Cub. ft. per lb. gross.
Fusing colour on sheet iron	840	1,130	2,230	11.8	4.78	1.98
Degreasing sheet iron	840	1,620	2,770	10.63	4.27	1.77
Enamelling cast iron	740	1,335	1,720	—	1.84	1.28

on spot tests, whereas those for coke refer to a whole quarter's operation. The results obtained may be considered in the same order as before.

Frit Melting

In this case information is only available on gas-fired installations. In one case the installation consists of two rotary furnaces, 4 ft. in dia. by 7 ft. 6 in. long, and capable of producing 500 lbs. per batch, the average time of melt being 2½ hrs. These are fired with low-pressure gas and air at 8 in. w.g. pressure, and temperatures up to 1,350 deg. C. can be obtained. The average results over about nine months' working are:—

For primary coats, 0.049 therm per lb. of frit = 9.8 cub. ft. per lb. (500 C.V.); for white coats, 0.05 therm per lb. of frit = 10 cub. ft. per lb. (500 C.V.).

In a second installation of the same kind, also consisting of two rotary furnaces but used much more intermittently, the results obtained on a spot test, starting with a cold furnace, and making frit for primary coats, were:—

0.0725 therm per lb. of frit = 14.5 cub. ft. per lb.

Drying

As an illustration of the type of results to be expected in the drying of castings after spraying, a test has been carried out on the conveyor oven installation previously referred to. This oven was working at a temperature of 130 deg. Fah. and the following test results have been obtained:—

A.—Throughput per hr., 7,360 lbs.; gas rate, 1,000 cub. ft. per hr.; giving a gas consumption per lb. of 0.136 cub. ft.

B.—Throughput per hr., 5,430 lbs.; gas rate, 690 cub. ft. per hr.; equivalent consumption, 0.125 cub. ft. per lb.

Fusing Enamel

Gas Firing.—Tests have been carried out on three separate installations, each consisting of a pair of gas-fired furnaces. In the first installation sheet-metal work alone was handled, one furnace being used for grip coats while the other dealt with the colour coats. In this case the nominal muffle size of the furnace was 15 ft. by 5 ft. The results are given in Table II.

In the second installation one furnace was used for cast iron and one for sheet, the nominal muffle size of the furnace being 12 ft. by 4 ft. 6 in. The results obtained are shown in Table III.

In the third installation one furnace was used for grip and the other for colour coats, but by special arrangement all the tests were carried out in the one furnace, the nominal muffle size being 15 ft. by 5 ft. The results obtained are shown in Table IV.

In reviewing these figures, the most consistent measurement would seem to be that of gas consumption per lb. gross load which varies between 1 and 2 cub. ft. Gas consumption per lb. net shows approximately a fourfold variation, while on sheet iron the consumption per sq. ft. varies from 7 to 12 cub. ft. These figures agree within the limits of accuracy with those published figures which the authors have been able to obtain, as, for instance, those given by T. R. Sawers.*

The results claimed for continuous furnaces are, of course, very much better than those given above, being of the order of 2.4 cub. ft. per sq. ft. of surface enamelled, but of these furnaces the authors have no actual experience.

Fuel Oil.—Tests have been carried out on two separate installations, a single furnace being examined in each case. For various reasons, these figures cannot be considered as precise as those obtained on gas firing, and there was, in fact, considerable difference between the results on the two installations. The figures obtained on the second installation have had to be omitted, since the only method of measuring the oil supply was by meter, and the instrument used was found after the test to be giving extremely erratic readings at the rate of flow obtained in practice. It is only fair to state, however, that the results on the second installation appeared to be appreciably better than those obtained on the first installation. The results are shown in Table V, and refer to a furnace 12 ft. by 4 ft. 6 in.

Coke.—Results obtained on coke are based, not on a spot test, but on a quarter's actual operation with four furnaces with a nominal area of 9 ft. 6 in. by 4 ft., working 144 hrs. per week. These figures are obviously not strictly comparable with those previously quoted, since the rate of throughput must be very much less over an extended period. Furthermore, the output figure is based not on the quantity of material actually passing through the furnace, but on the quantity despatched during the corresponding period, so that no allowance has been made for refirings, rejects, etc. Working on this basis, it has not been possible to analyse the figures to obtain separate results for grip and colour coats, but no cast-iron work is included. The results are set out in Table VI.

* "Gas World," Vol. 102; "Industrial Gas Supplement," March 16, 1935.

Table IV.—*Operating Data for Various Processes.*

Process.	Temp., deg. C.	Throughput. Lbs. per hr.	Gas consumption (500 C.V.). Cub. ft. per hr.	Cub. ft. per sq. ft.	Cub. ft. per lb. net.	Cub. ft. per lb. gross.
Fusing grip (flat loads)	875	1,980	3,290	9.5	5.27	1.66
,, ,, (stand loads)	875	2,850	3,570	8.2	4.43	1.23
Fusing colour (flat loads)	800	2,390	3,530	7.85	4.31	1.48
Annealing castings (stand loads) ..	800	2,510	2,680	—	1.56	1.07

Table V.—*Operating Data for Oil-fired Muffle.*

Process.	Temp., deg. C.	Throughput. Lbs. per hr.	Oil consumption. Galls. per hr.	Galls. per lb. gross.	Equiv. gas cons. per lb. gross.
Fusing colour on sheet iron	840	1,000	9.37	0.0086	3.06
Fusing grip on sheet iron	880	1,000	9.81	0.0098	3.48

Table VI.—*Operating Data for a Coke-Fired Muffle.*

Period of test.	Total output. Sq. ft.	Coke consumption. Total consumed.	B.T.U. consumed.	B.T.U. per sq. ft. of surface.	Equiv. gas consumed, 500 C.V.	Equiv. gas consumed per lb. net.
13 weeks	1,534,000	370 tons	107.8×10^9	7,020	14.1	8 cub. ft.

Conclusions

In conclusion, it may be worth pointing out that in the past few years there have been innumerable occasions when town gas has been adopted for processes previously carried out by means of cheaper fuels, producer gas, coal or fuel oil, even when fuel cost was a major item in determining the production cost of the article. Very often the manufacturers responsible began by feeling that the great difference in raw fuel could never be adequately made up for by such increases in efficiency as have been suggested in the first section of this Paper. In almost every case, a trial of town gas firing, providing only that the most suitable furnaces or appliances were installed, has shown that the incidental advantages easily outweigh the increase in fuel cost, which is often much less than has been anticipated.

In illustration of this point, two representative processes might perhaps be quoted in which town gas has recently made great strides, heat-treatment of ferrous metals and bread baking. In both of these processes fuel cost is of prime importance, and until recently low-priced fuels were almost universally employed. Since the war, however, gradual improvements in the technique of gas firing and the general realisation of the advantages associated with flexible fuels have combined to increase the consumption of town gas for these processes very greatly. Another factor which has certainly played its part in this development is the tendency for gas prices for industrial work to be reduced. On this analogy, it would seem justifiable to conclude that vitreous enamelling is likely in the near future to provide a useful field of application for town gas.

Recrystallisation of Electrolytic Iron

From his investigations on the recrystallisation of electrolytic iron, described in Report No. 287 of the Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung zu Düsseldorf, G. Wassermann concludes that rolled electrolytic iron recrystallises with a fine grain, while heating above the A_3-point (recrystallisation) results in a fairly coarse-grained structure. By quenching from the γ-state it is possible to keep the recrystallised grain in a finer condition. If electrolytic iron is allowed to cool from the γ-state that the transformation temperature is gradually displaced along the test-bar, small elongated rod-like crystals are obtained, whose formation is the more perfect the slower the rate of cooling. In the formation of these crystals adjoining α-crystals frequently act as nuclei. During recrystallisation, Armco iron and low-carbon steel behave quite differently from electrolytic iron, for with the former the recrystallised structure is always very fine-grained, and rod-like crystals never appear. The formation of the latter is ascribed to the fact that the number of nuclei of α-crystals in γ-α-transformation is very small, and only increases with rising temperature.

Spray Guns for Vitreous Enamelling

MODERN DEVELOPMENTS DISCUSSED

Capt. Whiteman's Paper on this subject, which appeared in last month's Vitreous Enamelling Section, gave rise to an interesting discussion. It was opened by the CHAIRMAN (MR. B. B. Kent), who remarked that he agreed with most of the points mentioned by the author, and believed that enamellers would gain a great deal if they practised them in their work. With regard to the advice that great care should be taken of the spraying guns, he had found it good practice to have a glass-fronted cabinet in which all the guns were placed at the end of the day's work. In that way dust and dirt could be prevented getting in the guns during the night. With regard to the relative advantages of pressure and gravity feed, he could not say that in his own case any great success had been achieved in spraying cast iron using pressure feed, although pressure feed was used with sheet iron. As the author had said he hoped to learn something from the discussion, he would like to suggest that the question of constructing a gun with a double nozzle, which could be used for ordinary spraying and also for mottling, would be worth his consideration. For straight spraying the trigger would be depressed half way and for mottling full back.

Material for Nozzle Tips

MR. H. CAMERON, speaking with regard to the gun construction, said that at one time the tips were constructed of bronze and there was no corrosion. Now, however, guns were manufactured with steel tips, and he had found that with this type it was possible for rust to accumulate inside. Could the author say whether these tips could be made of stainless steel or similar material? He believed that in America a pressure of 90 lbs. was used, but he could not work with anything like that pressure. It was also a fact that the Americans used an enamel with a much lower viscosity than was the case in this country.

MR. J. H. COUPE, referring to the pressure-feed system, asked if there was not a greater possibility of oil getting into the air and contaminating it as compared with the gravity-feed system.

MR. E. CHIFFEY asked whether the new type of gun described by the author which contained four spreading jets was suitable for cellulose spraying as well as for vitreous enamelling. With regard to the author's comments as to the advantage of having the exhaust trunking widened at the end, he asked for a technical explanation of the advantage of this.

The CHAIRMAN, commenting on the do's and don'ts mentioned by the author in order that the best results might be obtained, asked whether it would be possible for his firm, and other gun manufacturers, to have a small poster printed which could be exhibited for the benefit of the operators. If such a poster could be provided, enamelling firms would appreciate it very much.

MR. K. HILL suggested there might be some difficulty in cleaning the very small holes in the gun, after a period of use.

MR. J. H. COUPE asked the author whether, in cases where there was both a day and a night shift, he would recommend that the two shifts should have separate guns and that each be responsible for their own.

MR. HILL asked whether anything had been done with regard to the use of an aluminium alloy for reducing the weight of the guns. There was necessarily a certain amount of fatigue in the use of this apparatus, and if the weight could be reduced, it would be a great advantage.

AUTHOR'S REPLY

The Question of Mottling

Before replying to the discussion, CAPT. WHITEMAN said that he would like to make a few remarks on the question of mottling, as it was a matter on which there appeared to be considerable difference of opinion among enamellers, and he was therefore rather disappointed that the subject had not been raised during the discussion, as he had been hoping to learn something useful.

The author stated that, in his opinion, one of the first things to do in order to produce a mottle of uniform character was to eliminate the human element as far as possible by reducing to a minimum the number of operators engaged on mottling—for example, if 24 operators were working in a plant—it would be better to allow, say, 18 of them to concentrate on cover coat work and to put the remaining six on mottling rather than to let all 24 operators do both classes of work. The six operators who were mottling regularly would become much more efficient in applying a mottle of regular character than if they had to apply cover coats as well. The likelihood of obtaining different sized spots owing to individual operators' method of using the spray gun would also be much reduced, so that the final result when the pieces were assembled would tend to be more uniform.

Capt. Whiteman said that in the United States a considerable amount of mottling was done on large pieces with the type of spray gun he had described for cover coats, but fitted with a special mottling head. In such cases, the enamel was fed to the gun from a pressure feed tank, which ensured a better control of the enamel than in the case of a mottling gun of the attached cup type, as well as eliminating waste of time for refilling. The author added that mottling guns of the attached cup type were very satisfactory for certain sizes and forms of work and where the percentage of mottling enamel used as compared with cover coat enamel was low, but he strongly recommended the larger spray gun he had described for mottling with a pressure feed tank in cases where large surfaces were treated or where the percentage of mottling enamel applied was high.

In regard to the Chairman's suggestion that a gun might be produced that would mottle and also apply cover coats, Capt. Whiteman said he felt that for the time being it would be better to keep the two operations apart, for if the best results were to be obtained, such a combination gun would need to be used by very intelligent and careful operators, and, unfortunately, such operators were not always available. He added that he would certainly consider the possibility of producing such a gun very carefully. In answer to the Chairman's further suggestion that a small poster should be produced giving concise instructions for the care of spray guns, the author agreed that it was an excellent idea, which he would be very pleased to adopt as soon as possible, as there was no doubt that the carefully produced instruction bulletins issued by spray-equipment manufacturers were only too frequently not read by the operators.

Stainless Tips

In connection with Mr. Cameron's statement that he had recently received ordinary steel fluid tips that had rusted in use, Captain Whiteman stated that it was evident that a mistake had occurred, as it had long been the practice of his company to supply fluid tips of stainless steel, Monel Metal, or other specially treated metal for use with vitreous enamel. The pressures used for the application of vitreous enamel in the United States were generally higher than those usually employed in this country—pressures up to 90 lbs. per sq. in. were common in America, whereas very good results were being obtained in this country at pressures of from 50 to 75 lbs. per sq. in.

Captain Whiteman added that the question of the best pressure to use depended very largely on the viscosity of the enamel, and he said that the best pressure to use was that which would efficiently atomise the particular material being used and at the same time enable the surface to be covered with sufficient speed. The author said that the tendency in America was now towards lower pressures, particularly since the introduction of the new type of air cap he had described in his Paper.

Oil Contamination

In answer to Mr. Coupe, the author said there was no more chance of oil getting through to the spray gun with the pressure-feed system than in the case of the gravity-feed container, and the risk of getting oil in the compressed air was exactly the same in both types of feed if the precautions he had explained for obtaining oil-free air were not taken.

He did not personally see any objection to the day and the night shifts using the same guns—in one of the largest motor-car factories in the world the practice was for the spray guns to be collected by the gun-maintenance department when the day shift came off work, and after testing and adjustment the guns were re-issued to the night shift.

Referring to Mr. Chiffey's question, Captain Whiteman stated that the new type of air cap he had described was equally suitable for the application of cellulose and synthetic lacquers and that it had enjoyed a very gratifying success in those fields—he added that there were slight differences in the sizes of the holes in the cap and in the angles of the jets to suit the different viscosities of cellulose and synthetic lacquers.

In regard to Mr. Hill's question, the author stated that there was no more tendency for the holes in the new type of air cap to clog up than in previous types unless the operators did not take the trouble to keep the cap clean. As to the use of an aluminium alloy for the construction of spray guns, it had been the practice of the author's company for some considerable time to manufacture spray guns from high-pressure Duralumin stampings which were very light, strong and non-porous. He added that some people still preferred the guns to be made of brass to resist the abrasive action of vitreous enamel, but such guns were naturally very heavy, and this tendency was rapidly dwindling.

Whilst he was not sure whether his firm's laboratory had made any experiments with Fuller's earth as a means of removing oil from compressed air, they had used silica gel and calcium chloride in this connection. He added that he would go into the question of tests with Fuller's earth as well as with trichlorethylene, as suggested by the Chairman, and that if satisfactory results had been obtained he would communicate details to the Institute in due course. The author detailed an ideal installation he had made some years ago showing the best method of compressing the air and conveying it to the spray guns in order to eliminate oil and moisture.

Standardisation

Captain Whiteman said that the question that had been raised concerning the different thread sizes used by manufacturers of spraying equipment was one to which his company had given very careful consideration, but unfortunately for the time being there did not appear to be any solution. In conclusion, he said that spray-equipment manufacturers naturally did not care to change the sizes they had been using for many

(*Concluded on page* 200.)

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This Week's News in Brief

Trade Talk

HEAD, WRIGHTSON & COMPANY, LIMITED, of Thornaby-on-Tees, have installed an additional electric furnace to meet the increased demand for special alloy steels.

AT A MEETING of the Stanton Ironworks Sports Association, Mr. R. Sharp, chairman, announced that the company intended to provide a new institute on the sports ground.

THE NEW PLANT at the works of the Staveley Coal & Iron Company, Limited, for the production of 3-in. and 4-in. dia. spun pipes, 12 ft. long, will probably be in operation this week.

J. L. THOMPSON & SONS, LIMITED, Sunderland, have received an order for a cargo steamer of 9,250 tons for Charles G. Dunn & Company, Liverpool. The engines will be built by Richardsons, Westgarth & Company, Limited, Sunderland.

A JOINT MEETING of the Welsh Engineers' and Founders' Association and the West Wales Engineering Trades' Committee was held in Swansea last week to consider an application from the employees for an increase in wages of 2s. 6d. per week. It was decided to adjourn the matter until March 20.

HURST, NELSON & COMPANY, LIMITED, Flemington Works, Motherwell, have received an order to build 50 of the 250 wagon chassis required by the L.M.S. Railway Company for conveying road-rail containers. All the chassis are intended for carrying meat traffic containers of the "FM" or "BR" insulated types.

EXTENSIONS AND ALTERATIONS which are now being carried out at the Brymbo Steel Works at Wrexham will increase the productive capacity of the works by 25 per cent. A new 50-ton open-hearth furnace and a 150-ton metal mixer are to be installed. The extensions will, it is anticipated, be completed by the end of next June.

THE FISCHER BEARINGS COMPANY have acquired a large portion—approximately one-third—of the Moorfield Works, Wolverhampton, from the owner, Mr. F. H. Farrar, of the Villiers Engineering Company. It is expected that the work of equipping the factory for the manufacture of steel balls and bearings of all types will begin almost immediately.

COLVILLES, LIMITED, Dalzell Steel Works, Motherwell, have secured permission from the British Steel Trades Confederation to extend the working hours temporarily by the addition of a Sunday shift from 2 p.m. to 10 p.m. to enable the firm to increase its output and to complete certain orders within the stipulated time. The concession has been granted for a period of nine weeks.

A NEW COMPANY has been registered under the title of D. & W. Henderson, Limited, Meadowside Works, Glasgow, with a capital of £120,000, to carry on as a going concern the business of ship repairers carried on by D. & W. Henderson & Company, Limited, now in liquidation. The directors include Mr. John Craig, C.B.E., chairman and managing director of Colvilles, Limited.

EMPLOYEES OF Royles, Limited, Irlam, near Manchester, received a 12 per cent. bonus on their wages during 1935, and a total of £4,181 was distributed among 200 of them last week. This is the sixteenth year the firm has paid an annual bonus to its workers, totalling a sum of £45,000, which averages 9 per cent. In an interview, Mr. Allan Royle, director, said that the firm had good order-books, and the prospects for 1936 were equally favourable.

THE ADMIRALTY have decided, subject to adjustment of certain details, to entrust the building of H.M.S. "Ghurka" and H.M.S. "Maori" to the Fairfield Shipbuilding & Engineering Company, Limited, Govan, and H.M.S. "Zulu" to Alexander Stephen & Sons, Limited, Linthouse, Glasgow. These three orders raise the total number of destroyers building on the Clyde to about a dozen. Other Admiralty work on hand includes three 9,000-ton cruisers, two sloops, one submarine, one survey ship, one net layer and several other vessels nearing completion.

Forthcoming Events

MARCH 6.

Manchester Association of Engineers:—Dinner and Dance at the Manchester Limited Restaurant.

MARCH 13.

Institute of Welding (Midlands Branch):—"Influence of Welding on Design," Paper by S. E. Evans, at the James Watt Memorial Institute, Newball Street, Birmingham, 3, at 7.15 p.m.

MARCH 14.

Keighley Association of Engineers:—Annual Dinner, at the Queen's Hotel, Keighley; Reception at 5.45 p.m.

Institute of Metals

MARCH 9.

Scottish Local Section:—"Centrifugal Casting of Non-Ferrous Metals," Paper by F. W. Rowe, B.Sc., at the Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, at 7.30 p.m.

MARCH 11 AND 12.

Annual General Meeting of the Institute, at the Institute of Mechanical Engineers, Storey's Gate, London, S.W.1, at 10 a.m.

MARCH 13.

Sheffield Local Section:—Annual General Meeting, in the Non-Ferrous Section of the Applied Science Department of the University, St. George's Square, at 7.30 p.m.

Institute of British Foundrymen

MARCH 7.

East Midlands Branch:—Annual Dinner, at Loughborough College, Loughborough, at 6 p.m.

Lincolnshire Section:—Students' Papers, at the Technical College, Mark's Road, Lincoln, at 7 p.m.

Lancashire Branch:—Ten-minute Papers, at the Engineers' Club, Albert Square, Manchester, at 4 p.m.

MARCH 10.

Burnley Section:—Annual General Meeting; "Influence of the Various Metalloids on Cast Iron," Paper by D. Malone, at the Municipal College, Ormerod Road, Burnley, at 7.15 p.m.

MARCH 14.

Scottish Branch:—Annual General Meeting; presentation of "John Surtees" prizes; "Castings," Paper by W. Machin and M. C. Oldham, at the Royal Technical College, George Street, Glasgow, at 4 p.m.

Personal

MISS HELEN DEWAR has been presented by her colleagues of the laboratory staff of the British Aluminium Company, Limited, Kinlochleven, with a leather travelling case on the occasion of her leaving for Aberdeen.

MR. T. A. DENTON, of Newburn-on-Tyne, has been appointed the Jarrow-on-Tyne representative of Thos. W. Ward, Limited, of Sheffield, in connection with the breaking-up of Palmer's steelworks. He succeeds the late Mr. Edwin Hargreaves.

MR. F. W. WILSON, assistant manager at Jarrow, supervising the breaking-up of the former Cunard-White Star liner "Olympic" for Thomas W. Ward, Limited, Sheffield, has joined William Gray & Company, Limited, of West Hartlepool, shipbuilders and marine engineers.

MR. A. G. E. BRIGGS, special director and sales manager of the English Steel Corporation, has been appointed a director of the Darlington Forge, Limited. He served his apprenticeship with Vickers, later joining their sales staff at the London office. He was for a time associated with Ibbotson Bros. & Company, Limited, and made a tour of the South American States on their behalf. Afterwards he rejoined Vickers as sales manager of the English Steel Corporation, and a year ago was appointed special director.

Obituary

MR. JAMES WILSON, patternmaker at the Caledonian Foundry Company, Limited, Greenock, collapsed and died in the works on Tuesday morning of last week.

THE DEATH HAS OCCURRED of Mr. Archibald Rennie, of Greenock. Mr. Rennie, who was in his 65th year, had been chief draughtsman with Scott's Shipbuilding & Engineering Company, Limited, for many years.

MR. WILLIAM FREDERICK BEARDSHAW, J.P., of Sandygate Park, Sheffield, died on February 28, at the age of 78 years. He was chairman of J. Beardshaw & Son, Limited, Baltic Steel Works, Sheffield, and had been associated with them for over 50 years. Mr. Beardshaw had been a member of the Iron and Steel Institute since 1889, and for three years he was President of the Sheffield Society of Engineers and Metallurgists. He was also a member of the Institute of Civil Engineers.

Spray Guns for Vitreous Enamelling

(Concluded from page 198.)

years, as it would be very inconvenient to their customers, but he was hopeful that a solution of this difficulty would eventually be found.

Vote of Thanks

MR. MCCALLA, proposing a vote of thanks to the author, said what had impressed him most in listening to the Paper was the many advances which had been made in matters which to him some years ago were but a dream. Now they had been transformed into realities. It was exactly 38 years ago since he had put the first vitreous enamel on glass, and at that time the only thing available to do this work with was a little instrument very different from the present spray gun. (A spray gun of the earlier type was exhibited.) It was 38 years ago, continued Mr. McCalla, that he made contact with Mr. Burdett, the inventor of the Aerograph, and it was pleasing to know that Mr. Burdett was still alive to-day. One matter which had impressed him particularly was this question of pressure, to which he had devoted a great deal of time and thought. He fully agreed with Mr. Cameron that high pressures were entirely wrong, and that had been confirmed by experience. It was some 27 years ago since he invented the metal tile, and the day had arrived when he had to turn them out in many thousands at a time. As a matter of fact, there were millions of them used in the Underground Railways of London. At the start, the difficulty was to get the enamel to remain on the edges of the tiles. The tiles used to be enamelled in groups of 15 on a bar; the sprayer was trained on the edges, and the remainder of the tile was left to look after itself, but he then found that it was due to the pressure being too high that the enamel would not stay on the edges of the tiles. So convinced was he that the pressure was wrong that he had valves put on the air line so that the pressure did not exceed 32 lbs. per sq. in. After that there was no more trouble with getting the enamel to remain on the edges, and the work became almost automatic.

Referring to the question of keeping spray guns clean, Mr. McCalla said that at one time he had 24 operators at work, and there was so much trouble with guns going wrong that it was no uncommon thing for an operator whose gun had failed to wait an opportunity and steal the gun of another operator which was working satisfactorily. Incidentally, he said the operators were females. He therefore decided to keep a register of the guns, and although prizes were not offered to the operator who kept the cleanest gun, there was the promise that the operator who had the best record in this respect had the next new gun that was bought from time to time. There was, as a matter of fact, great competition for the new guns, and as a result the guns were kept in a much better condition than had been the case formerly. There was also a great deal in the remark made by Mr. Coupe that one operator should only be allowed to use one particular gun. Certainly, he would never allow the day and night operators to use the same guns, otherwise it was impossible to lay the responsibility of taking care of them upon any operator. In conclusion, Mr. McCalla remarked that the modern spray guns were a good deal more complicated than the simple guns he had used years ago, but the quality of the work done was very much improved.

MR. CLAYTON, seconding the vote of thanks, remarked that the advice which the author had given was undoubtedly sound practice. The vote of thanks was given with hearty acclamation.

THE BRANCH OFFICE of Messrs. Callender's Cable & Construction Company, Limited, in Southampton has moved to larger premises at 17, Strand.

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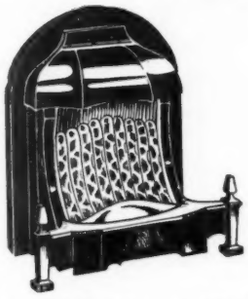

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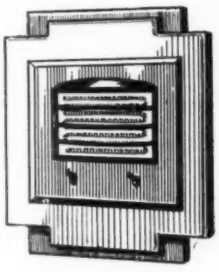

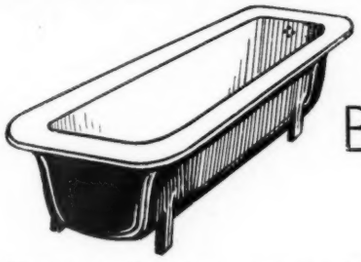

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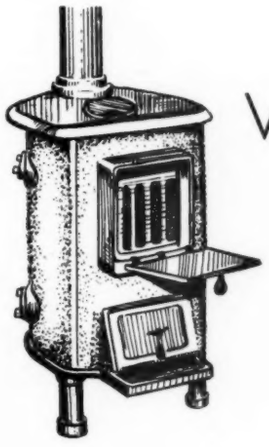
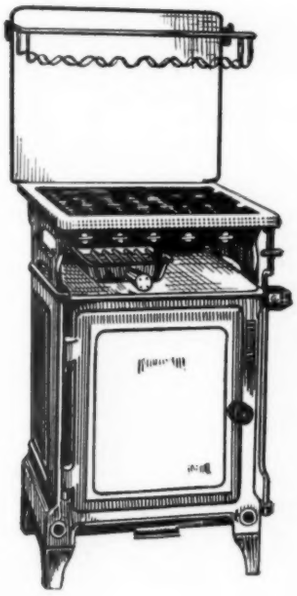
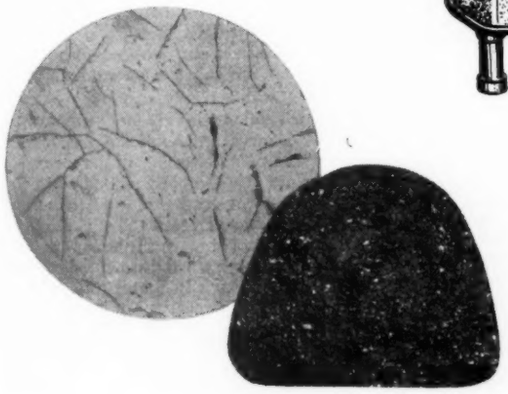


VITREOUS

ENAMELLING





ANALYSIS

	%
Graph. Carbon	3.16
Comb'd Carbon	0.3
Total Carbon	3.46
Silicon	3.0
Sulphur	0.02
Phos.	1.35-1.55
Mang.	0.44

The Stanton Ironworks Company Limited, Near Nottingham

The Largest Producers of Foundry Pig Iron (for sale) in Great Britain

Raw Material Markets

Producers continue to refrain from entering into forward commitments, but the demand is very heavy and, when the question of prices is finally settled, further business is likely to be brought out. The production of foundry iron has been sold for some months ahead, and makers are asking for a premium of 5s. per ton for deliveries after the end of June.

Pig-Iron

MIDDLESBROUGH.—Dorman, Long & Company, Limited, have reconstructed a large blast furnace at their Acklam Works to produce an increased output of 2,500 tons per week. However, this change will not result in any extra iron being available on the market. Steelworks continue to require very heavy supplies of basic iron. Deliveries of Cleveland foundry iron are becoming still further behind schedule, and new business cannot be considered. Prices are expected to be increased in the near future; nominally No. 3 Cleveland G.M.B. stands at 70s. per ton delivered Middlesbrough or Falkirk, 72s. delivered North-East Coast, and 73s. delivered Clydeside.

Most producers of East Coast hematite are now being forced to draw upon their stocks in order to comply with their commitments. The question of prices is still uncertain, and until these are officially ratified business will continue to be affected. The recently increased quotations are taken as the basis of new business.

LANCASHIRE.—Very little forward buying is taking place in this area at the present time owing to the fact that most foundry-iron consumers are well contracted for supplies. Deliveries are being taken up against specifications, but in some cases these are a little belated. Pig-iron consumption during February was quite satisfactory. Offers of Staffordshire, Derbyshire and Lancashire brands of No. 3 iron for delivery to users in the Lancashire price zone are all on the basis of 78s. per ton for delivery up to the end of June, and 83s. for delivery after that period, with Northants at 76s. 6d. and 81s. 6d. respectively. Scottish foundry iron is well held at 87s. 6d., delivered equal to Manchester. There is a fairly good demand for hematite, with West Coast material quoted at around 85s. 6d. per ton and East Coast at from 84s. 6d. to 85s., both delivered equal to Manchester.

MIDLANDS.—A meeting of pig-iron producers was held last week, but prices were left unchanged. An increase would have caused no surprise, as makers have been asking 5s. premium for delivery after June 30. The minimum Association quotations are still 72s. 6d. per ton for No. 3 Northants and 75s. for Derbyshire, Lincolnshire and North Staffs No. 3, delivered Birmingham and Black Country stations. A small sliding-scale rebate is granted to large consumers. A fair amount of new business has been contracted, and the 5s. premium is being paid. Both light and heavy foundries are taking up satisfactory tonnages of iron. The general engineering, jobbing and motor trades are active, and are requiring good supplies of pig-irons other than the ordinary local grades. The current quotations are £6 10s. to £7 15s. for refined iron, 80s. to 87s. 6d. for medium-phosphorus, and 92s. 6d. to 100s. for low-phosphorus iron, delivered to local stations. Consumers of hematite in this area are using large tonnages, and some difficulty is being experienced in obtaining full requirements. Present quotations delivered Birmingham and Black Country stations are £4 7s. 6d. per ton for East Coast No. 3, £4 8s. 6d. for West Coast mixed numbers, and £4 7s. for Welsh mixed numbers. For delivery into works 1s. 6d. extra is charged.

SCOTLAND.—Unchanged conditions prevail in the Scottish pig-iron market. Consumers are having some difficulty in obtaining their full requirements. New business is scarce, most users being well covered for supplies. Prices are unaltered, and 74s. f.o.t. furnaces for No. 3 foundry is still quoted, with 2s. 6d. extra for No. 1. Several of the Falkirk founders are unable to secure all their needs of Cleveland iron, and they are having to press local and Midland makers for additional tonnages. No. 3 Cleveland is still quoted at 70s. f.o.t. Falkirk and 73s. f.o.t. Glasgow, with other English foundry iron quoted at 1s. 3d. per ton below these figures. The steelworks are well employed. There is no change in the prices of steelmaking irons. Mixed numbers of East Coast, West Coast and Scottish hematite are 77s. and basic iron, British and Indian, 70s. (less 5s. rebate), all delivered steelworks.

Coke

The demand for supplies of foundry coke is a little less keen than it was a month or so ago. However, the position remains firm. Prices are unchanged. For delivery to Birmingham and district supplies of best Durham coke are quoted from 41s. 6d. to 43s., and Welsh coke from 38s. 6d. up to 50s. per ton.

Steel

The activity in the steel market has been maintained and many of the departments are operating at capacity, says the official report of the London Iron and Steel Exchange. The demand for semi-finished material is still in excess of the supply, and in spite of the additional tonnages of Continental billets which have been imported, there appears to be no slackening in the demand from the home makers. The majority of the works are unable to give near delivery, and the producers have enough orders in hand to absorb their output for some time to come. In the finished-steel section new business has been rather quiet in one or two departments, probably as a result of consumers having covered their requirements before the recent rise in prices. Business in structural steel is active, and in the lighter branches of the industry production is on a good scale. In some instances consumers are finding it difficult to cover their needs, and report that deliveries against current contracts are falling into arrears.

Scrap

The demand for heavy melting steel scrap in the Cleveland area is such that, in spite of very heavy importations from abroad, it is still impossible to find adequate tonnages. The current quotation is 57s. 6d. per ton delivered works. Good machinery metal has also been imported, and supplies are on offer at 63s. 6d. per ton, while ordinary heavy foundry cast iron has a good demand at 52s. 6d.; a few sellers are still demanding 53s. 6d. per ton. All qualities of scrap have a steady demand on the Midlands market, and prices have become much steadier. Heavy machinery metal in cupola sizes is at 60s. to 62s. 6d., good heavy 55s. to 57s. 6d., and clean light at 52s. 6d. Short, heavy, steel scrap, as used in the foundries, is at 65s. per ton delivered works. Active conditions continue to prevail on the Scottish market, and imported supplies are being utilised to supplement local material. Heavy mild-steel melting scrap has a fair demand at 57s. 6d. Heavy basic, or heavy iron and steel scrap mixed, remains at 52s. 6d. Supplies of heavy machinery cast-iron scrap, in pieces not exceeding 1 cwt., are realising around 70s., while for good, clean, ordinary cast-iron scrap, suitable for foundry purposes, and in pieces not exceeding 1 cwt., the price is 65s. to 66s. per ton, delivered f.o.t. consumers' works.

Metals

Copper.—There has been a slight falling away of buying interest in this metal during the past week. The trade demand at the beginning of the week was on a moderate scale, but has since declined. However, as many of the producers are sold well ahead, they are not pressing sales. The uncertain price position in the United States remains, but some stabilisation is expected in the near future. The American Bureau of Metal Statistics have issued the following details in connection with the output in 1935:—Russia's output increased from 48,600 tons to 72,900 tons, while the Canadian output increased from 168,200 tons in 1934 to 193,700 tons in 1935. The Chilean figures were 271,600 tons and 286,400 tons respectively.

Daily market prices :—

Cash.—Thursday, £35 10s. to £35 12s. 6d.; Friday, £35 12s. 6d. to £35 13s. 9d.; Monday, £35 10s. to £35 11s. 3d.; Tuesday, £35 11s. 3d. to £35 12s. 6d.; Wednesday, £35 17s. 6d. to £36.

Three Months.—Thursday, £35 17s. 6d. to £36; Friday, £36 to £36 1s. 3d.; Monday, £35 16s. 3d. to £35 18s. 9d.; Tuesday, £35 18s. 9d. to £36; Wednesday, £36 3s. 9d. to £36 6s. 3d.

Tin.—Further criticism has been directed against the decision of the International Tin Committee to reduce the quota. This has been accentuated by the increasing tightness in the prompt position. Buying is on a low scale in this country, but deliveries are fairly heavy. In the United States conditions are only moderate. Members of the London Metal Exchange have formed a committee, which at a meeting on Friday decided to draw the attention of the British Government to the seriousness of the present shortage of tin in this country.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £213 to £214; Friday, £212 10s. to £212 15s.; Monday, £209 to £210; Tuesday, £209 5s. to £209 15s.; Wednesday, £210 10s. to £211.

Three Months.—Thursday, £203 to £204; Friday, £203 10s. to £203 15s.; Monday, £201 7s. 6d. to £201 10s.; Tuesday, £201 10s. to £201 15s.; Wednesday, £202 5s. to £202 15s.

Spelter.—Little change has occurred in this market during the past week. The brass trade is active in this country, but the galvanising industry is still very subdued. Meetings have been held in connection with the revival of the International Zinc Cartel, but little headway has been made and considerable difficulty has been met. The American Bureau of Metal Statistics gives the world's output of spelter during January as 133,000 tons, against 130,000 tons in December.

Official quotations were as follow :—

Ordinary.—Thursday, £15 17s. 6d.; Friday, £16 3s. 9d.; Monday, £15 15s.; Tuesday, £16; Wednesday, £16 2s. 6d.

Lead.—Steady conditions have prevailed in this market recently, but the world outlook is rather obscure at the present time. The building trade is expected to take up increased supplies in the near future and the armament programmes are also likely to consume heavy tonnages of lead. Rather more activity has been apparent in the United States.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £16 8s. 9d.; Friday, £16 8s. 9d.; Monday, £16 5s.; Tuesday, £16 6s. 3d.; Wednesday, £16 7s. 6d.

South African Engineering Industry Co-operation

The Transvaal Engineering and Allied Industries Federation has been undergoing reorganisation for some time past, and now consists of a number of associations federated to secure uniformity of policy and action in all matters of principle. At a recent meeting of the general membership of the Federation, it was determined that the Federation would forthwith establish an organisation separated from the Chamber of Industries, designed to embrace the interests connected with the fabrication and manufacture of iron and steel.

This new development is not unexpected, in view of the growth and expansion in the metal-manufacturing industries in recent years. Statistics show that about 450,000 to 500,000 tons of products of iron and steel are imported into South Africa each year. The Pretoria works are capable of turning out about one-third of this quantity to be turned into finished products by the 800 South African metal and engineering factories. South Africa each year imports into its four provinces about £20,000,000, sometimes £30,000,000, worth of finished materials and products, the basis of which is largely iron and steel. There is, therefore, considerable potential scope for manufacturing engineering in the Union. Already the industry is one of the foremost, if not the foremost, of secondary industries in the Transvaal. With the establishment of the new organisation, the metal industries will ensure both their recognition as an important factor in the community, and the direct representation of their interests, which in many respects are peculiar. Mr. A. H. Guy, of the Eclipse Tube Mills, is the President.

CROSSING THE BORDER

and the penalty

YOU see there are many good Iron Founders in the Midlands, and in the South for that matter, who have a secret yearning to mould again with a genuine Scottish Rock Sand, such as perhaps they have once been used to. They like the heavy bond, the coarse grains, the high permeability . . . Others have never known such luxuries.

The trouble comes from not being able to move large chunks of mother-earth down South from the banks and braes without the penalty of spending a lot of money—a deplorable thought!

But the merrily tapping of wayside rocks with our little geological hammers and our love of digging holes have taken effect. We've discovered nature's bounty in a natural rock moulding sand within easy reach of *the Midlands.* (EUREKA!)

It is christened Tor Rock Sand, and we baptize it with just enough water in a painstaking mill to give a wonderfully plastic, coarse, cohesive sand—a moulder's delight.

The scientific fellows say it's like this:—

CHEMICAL ANALYSIS.

Silica	86·8 %
Ferric Oxide	1·43%
Alumina	7·6 %
Lime	·22%
Magnesia	·18%
Titanic Oxide	·18%
Alkalies	1·8 %
Loss on ignition	1·6 %

MECHANICAL ANALYSIS.

Very Coarse Sand (+ 1 mm) ..	16·5%
Coarse Sand (+·5 mm − 1 mm) ..	16·0%
Medium Sand (+ ·25 mm − ·5 mm)	11·0%
Fine Sand (+ ·1 mm − ·25 mm) ..	30·0%
Silt Grade (+ ·01 mm − ·1 mm) ..	7·0%
Clay Grade (− ·01 mm)	19·5%

which doesn't explain everything, but we will if you will write to us.

GENERAL REFRACTORIES
LIMITED
Genefax House, Sheffield

Telephone: Sheffield 31113 (6 lines).
Telegrams: "Genefax, Sheffield."

LONDON OFFICE:
Russell House, Adelphi, W.C.2.
Telephone: Temple Bar 7361.
Telegrams: "Genefax, Rand-London."

SCOTTISH OFFICE:
156, St. Vincent Street, Glasgow.
Telephone: 3250.
Telegrams: "Genefax, Glasgow."

SOUTH WALES OFFICE:
11, Wind Street Swansea.
Telephone: 3680.
Telegrams: "Genefax, Swansea."

and Branch Offices, Works and Agencies throughout the world.

RAW MATERIALS—PRICE LIST

(Wednesday, March 4, 1936)

COPPER

	£ s. d.
Standard cash	35 17 6
Three months	36 3 9
Electrolytic	40 2 6
Tough	38 10 0
Best selected	38 15 0
Sheets	68 0 0
India	49 10 0
Wire bars	40 2 6
Ingot bars	40 2 6
H.C. wire rods	43 12 6
Off. av. cash, Feb.	35 7 0
Do., 3 mths., Feb.	35 14 3¼
Do., Sttlmnt., Feb.	35 7 0
Do., Electro, Feb.	39 14 0
Do., B.S., Feb.	39 2 6
Do., wire bars, Feb.	39 18 9
Solid drawn tubes	10½d.
Brazed tubes	10½d.
Wire	6¼d.

BRASS

Solid drawn tubes	9½d.
Brazed tubes	11½d.
Rods, drawn	8½d.
Rods, extd. or rlld.	5d.
Sheets to 10 w.g.	8d.
Wire	7½d.
Rolled metal	7¼d.
Yellow metal rods	5d.
Do. 4 × 4 Squares	5½d.
Do. 4 × 3 Sheets	5½d.

TIN

	£ s. d.
Standard cash	210 10 0
Three months	202 5 0
English	210 0 0
Bars	211 10 0
Straits	212 10 0
Australian	210 10 0
Eastern	208 10 0
Banca	211 10 0
Off. av. cash, Feb.	207 5 2¼
Do., 3 mths., Feb.	200 7 9
Do., Sttlmt., Feb.	207 5 3

SPELTER

	£ s. d.
Ordinary	16 2 6
Remelted	14 5 0
Hard	12 10 0
Electro 99.9	18 5 0
English	17 0 0
India	13 15 0
Zinc dust	19 10 0
Zinc ashes	4 5 0
Off. aver., Feb.	15 5 1½
Aver. spot, Feb.	15 2 6

LEAD

	£ s. d.
Soft foreign ppt.	16 7 6
Empire (nom.)	17 1 3
English	18 10 0
Off. average, Feb.	16 1 7½
Average spot, Feb.	16 0 5½

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	24 5 0
Do., V.M. ex-whse.	25 10 0
Rods	28 5 0

ANTIMONY

	£ s. d.
English	72 0 0 to 73 0 0
Chinese, ex-whse.	62 0 0
Crude, c.i.f.	30 10 0

QUICKSILVER

	£ s. d.
Quicksilver	12 0 0 to 12 10 6

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	8 17 6
45/50%	12 15 0
75%	17 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£21 0 0 to £22 0 0
Ferro-tungsten—	
80/85%	3/– lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	33 0 0
4/6% car.	21 15 0
6/8% car.	21 0 0
8/10% car.	21 0 0
Ferro-chrome—	
Max. 2% car.	33 10 0
Max. 1% car.	36 5 0
Max. 0.70% car.	37 5 0
70% carbon-free	9½d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	5/6 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese (net)—	
76/80% loose	£11 5 0 to 11 15 0
76/80% packed	£12 5 0 to 12 15 0
76/80% export	(nom.) £10 5 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/– lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/– lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£ s. d.	£ s. d.
South Wales—		
Heavy steel	3 5 0	to 3 7 6
Mixed iron and steel	3 0 0	to 3 2 6
Heavy cast iron	2 17 6	to 3 0 0
Good machinery	3 2 6	to 3 5 0
Cleveland—		
Heavy steel	2 17 6	
Steel turnings	2 0 0	
Heavy cast iron	3 0 0	to 3 2 6
Heavy machinery	3 3 6	
Midlands—		
Light cast-iron scrap	2 12 6	
Heavy wrought iron	3 7 6	to 3 12 6
Steel turnings	2 2 6	
Scotland—		
Heavy steel	2 17 6	
Ordinary cast iron	3 5 0	to 3 6 0
Engineers' turnings	2 2 6	
Cast-iron borings	1 17 6	to 2 0 0
Wrot-iron piling	3 8 9	to 3 10 0
Heavy machinery	3 10 0	

London—Merchants' buying prices, delivered yard.

	£ s. d.
Copper (clean)	29 0 0
Brass	19 10 0
Lead (less usual draft)	14 10 0
Tea lead	10 10 0
Zinc	8 10 0
New aluminium cuttings	74 0 0
Braziery copper	27 0 0
Gunmetal	27 0 0
Hollow pewter	155 0 0
Shaped black pewter	120 0 0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	72/6
,, No. 3	70/–
,, at Falkirk	70/–
,, at Glasgow	73/–
,, No. 4	69/–
Forge No. 4	69/–
Hematite No. 1	77/–
Hematite M/Nos.	76/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	77/–
,, d/d Birm.	88/6
Malleable iron d/d Birm.	119/–
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	71/–
,, No. 3 fdry.	75/–
Northants forge	68/6
,, fdry. No. 3	72/6
,, fdry. No. 1	75/6
Derbyshire forge	71/–
,, fdry. No. 3	75/–
,, fdry. No. 1	78/–
Scotland—	
Foundry, No. 1, f.o.t.	76/6
,, No. 3, f.o.t.	74/–
Hem. M/Nos. d/d	77/–
Sheffield (d/d district)—	
Derby forge	68/6
,, fdry. No. 3	72/6
Lincs forge	68/6
,, fdry. No. 3	72/6
W.C. hematite	90/–
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	78/–
Staffs fdry. No. 3	78/–
Northants fdry. No. 3	76/6
Cleveland fdry. No. 3	78/–
Dalzell, No. 3 (special)	102/6 to 105/–
Glengarnock, No. 3	87/6
Clyde, No. 3	87/6
Monkland, No. 3	87/6
Summerlee, No. 3	87/6
Eglinton, No. 3	87/6
Gartsherrie, No. 3	87/6
Shotts, No. 3	87/6

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)	10 2 6	
Nut and bolt iron	8 10 0	to 9 0 0
Hoops	11 0 0	and up.
Marked bars (Staffs) f.o.t.	12 10 0	
Gas strip	11 0 0	and up.
Bolts and nuts, ¾ in. × 4 in.	15 5 0	and up.
Steel—		
Plates, ship, etc.	8 15 0	to 8 17 6
Boiler plts.	9 5 0	to 9 7 6
Chequer plts.	10 7 6	
Angles	8 7 6	
Tees	9 7 6	
Joists	8 15 0	
Rounds and squares, 3 in. to 5½ in.	9 7 6	
Rounds under 3 in. to ⅛ in. (Untested)	9 1 0	
Flats—8 in. wide and over	8 12 6	
,, under 8 in. and over 5 in.	8 17 6	
Rails, heavy	8 5 0	to 8 10 0
Fishplates	12 10 0	
Hoops (Staffs)	9 16 0	
Black sheets, 24g. (4-t. lots)	11 10 0	
Galv. cor. shts. (,,)	13 10 0	
Galv. flat shts. (,,)	14 0 0	
Galv. fencing wire, 8g. plain	15 0 0	
Billets, soft	5 17 6	and up.
Billets, hard	6 17 6	to 7 2 6
Sheet bars	5 15 0	to 6 0 0
Tin bars	5 15 0	to 6 0 0

PHOSPHOR BRONZE

	Per lb. basis
Strip	10½d.
Sheet to 10 w.g.	11½d.
Wire	12½d.
Rods	11½d.
Tubes	14d.
Castings	12½d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1¼ to 1/7¼
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	21.31
No. 2 foundry, Valley	19.50
No. 2 foundry, Birm.	15.50
Basic, Valley	19.00
Malleable, Valley	19.50
Grey forge, Valley	19.00
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	36.37½
Billets	29.00
Sheet bars	30.00
Wire rods	40.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.85
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.80
Steel hoops	2.10
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.10
Wire nails	2.10
Plain wire	2.30
Barbed wire, galv.	2.50
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	27/6 to 32/6
,, furnace	20/6 to 21/6
Durham foundry	21/6 to 23/–
,, furnace	19/6 to 21/–
Scotland, foundry	30/–
,, furnace	25/– to 26/–

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	18/9 to 19/–
,,	28×20 ,,	37/6 to 38/–
,,	20×10 ,,	27/– to 28/–
,,	18¾×14 ,,	19/6
C.W.	20×14 ,,	16/–
,,	28×20 ,,	34/–
,,	20×10 ,,	28/3
,,	18¾×14 ,,	16/3

SWEDISH CHARCOAL IRON & STEEL

	£ s. d.	£ s. d.
Pig-iron	£6 0 0	to £7 0 0
Bars-hammered, basis	£16 0 0	to £16 10 0
Bars and nail-rods, rolled, basis	£15 15 0	to £16 0 0
Blooms	£10 0 0	to £12 0 0
Keg steel	£30 0 0	to £31 0 0
Faggot steel	£18 0 0	to £23 0 0
Bars and rods dead soft, st'l	£10 0 0	to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£ s. d.	
Feb. 27 ..	35 10 0	dec. 5/–
„ 28 ..	35 12 6	inc. 2/6
Mar. 2 ..	35 10 0	dec. 2/6
„ 3 ..	35 11 3	inc. 1/3
„ 4 ..	35 17 6	„ 6/3

Electrolytic Copper

	£ s. d.	
Feb. 27 ..	40 0 0	No change
„ 28 ..	39 15 0	dec. 5/–
Mar. 2 ..	39 15 0	No change
„ 3 ..	39 17 6	inc. 2/6
„ 4 ..	40 2 6	„ 5/–

Standard Tin (cash)

	£ s. d.	
Feb. 27 ..	213 0 0	inc. 65/–
„ 28 ..	212 10 0	dec. 10/–
Mar. 2 ..	209 0 0	„ 70/–
„ 3 ..	209 5 0	inc. 5/–
„ 4 ..	210 10 0	„ 25/–

Tin (English ingots)

	£ s. d.	
Feb. 27 ..	213 10 0	inc. 75/–
„ 28 ..	212 10 0	dec. 20/–
Mar. 2 ..	209 10 0	„ 60/–
„ 3 ..	209 5 0	„ 5/–
„ 4 ..	210 0 0	inc. 15/–

Spelter (ordinary)

	£ s. d.	
Feb. 27 ..	15 17 6	inc. 2/6
„ 28 ..	16 3 9	„ 6/3
Mar. 2 ..	15 15 0	dec. 8/9
„ 3 ..	16 0 0	inc. 5/–
„ 4 ..	16 2 6	„ 2/6

Spelter (Electro, 99.9 per cent.)

	£ s. d.	
Feb. 27 ..	18 0 0	inc. 2/6
„ 28 ..	18 5 0	„ 5/–
Mar. 2 ..	17 18 9	dec. 6/3
„ 3 ..	18 2 6	inc. 3/9
„ 4 ..	18 5 0	„ 2/6

Zinc Sheets (English)

	£ s. d.	
Feb. 27 ..	25 0 0	inc. 20/–
„ 28 ..	24 5 0	dec. 15/–
Mar. 2 ..	24 2 6	„ 2/6
„ 3 ..	24 5 0	inc. 2/6
„ 4 ..	24 5 0	No change

Lead (English)

	£ s. d.	
Feb. 27 ..	18 10 0	inc. 5/–
„ 28 ..	18 10 0	No change
Mar. 2 ..	18 10 0	„ „
„ 3 ..	18 10 0	„ „
„ 4 ..	18 10 0	„ „

AVERAGE PRICES OF GALVANISED CORRUGATED SHEETS (NORTH OF ENGLAND).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1905	10 7 6	10 7 6	10 7 6	10 7 6	10 7 6	10 7 6	10 7 6	10 7 6	11 0 0	11 5 0	11 15 0	12 0 0	10 15 0
1906	12 12 6	12 12 6	12 12 6	12 7 6	12 7 6	12 7 6	12 12 6	12 12 6	12 15 0	12 15 0	12 15 0	13 5 0	12 12 11½
1907	13 5 0	13 5 0	13 15 0	13 15 0	13 15 0	13 15 0	13 17 6	13 17 6	13 17 6	13 2 6	13 2 6	13 2 6	13 10 10
1908	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 11 0½
1909	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	10 10 0	11 0 0	11 0 0	11 0 0	11 0 0	11 16 8
1910	11 15 0	12 5 0	12 5 0	11 15 0	11 10 0	11 10 0	11 12 6	11 12 6	11 12 6	11 12 6	11 10 0	11 10 0	11 13 4
1911	11 5 0	11 1 3	10 15 0	10 15 0	10 13 9	10 10 0	10 13 9	11 0 0	11 5 0	11 5 0	11 5 0	11 7 0	10 19 7½
1912	11 10 0	11 10 0	11 10 0	11 15 0	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 12 6	12 18 0	12 15 0	12 2 11½
1913	12 15 0	12 15 0	12 15 0	12 11 3	11 18 0	11 15 0	11 15 0	11 15 0	11 15 0	11 3 0	11 0 0	11 2 6	11 18 4
1914	11 7 0	11 7 6	11 7 6	11 5 7½	11 2 6	10 15 0	10 15 0	12 17 6	13 7 0	11 15 7	11 2 6	11 16 0	
1915	11 10 8½	13 12 6	14 8 9	15 0 6	17 17 6	20 17 6	20 17 6	20 6 3	17 12 6	18 1 0	22 13 9	25 2 0	18 3 4½
1916	26 5 0	27 12 6	28 0 0	28 5 0	29 0 0	29 0 0	28 15 0	28 3 0	28 15 0	28 15 0	28 15 0	28 15 0	28 6 8½
1917	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 0 0	28 0 0	28 0 0	28 11 3
1918	28 5 0	28 15 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	28 13 4
1919	29 0 0	29 0 0	29 0 0	28 0 0	28 10 0	27 7 6	27 5 0	29 3 0	32 0 0	33 0 0	36 10 0	40 8 4	31 5 3½
1920	46 10 0	49 15 0	53 15 0	56 0 0	55 10 0	54 10 0	52 10 0	48 10 0	44 3 4	39 2 6	35 17 6	30 8 0	47 4 3
1921	28 10 0	25 17 6	24 5 0	23 3 4	22 0 0	22 0 0	23 10 0	21 12 6	20 0 0	18 15 0	18 3 9	17 2 0	22 1 7
1922	16 17 6	15 13 9	16 3 0	16 10 0	16 4 4½	15 15 6	15 16 3	16 16 0	16 8 9	16 6 3	17 1 0	17 7 6	16 7 5½
1923	18 3 1½	19 1 11½	19 8 0	19 10 0	19 7 0	19 1 3	18 0 0	18 13 1½	19 0 0	19 3 9	19 2 6	18 19 4½	18 19 2
1924	18 13 6	18 9 4½	18 5 0	17 15 11½	17 3 0	17 19 4½	18 7 6	18 8 1½	18 8 1½	17 19 6	17 11 3	17 10 0	18 0 10½
1925	17 8 6	17 1 6½	16 9 4½	16 12 0	16 9 8½	16 9 4½	16 0 6	16 1 10½	16 5 0	16 7 0	16 12 6	6 15 0	16 11 0½
1926	16 14 4½	16 5 7½	16 0 6	15 11 10½	15 11 3	16 0 0	16 16 0	16 18 9	16 14 0	16 18 9	17 10 0	6 19 0	16 10 0½
1927	16 3 1	15 7 6	15 3 3	15 3 1½	14 14 4½	14 11 6	14 1 10½	14 0 0	13 19 6	13 16 10½	13 13 1½	13 3 9	14 9 10
1928	13 0 0½	13 2 6	13 6 0	13 2 6	13 3 0	13 6 9	13 11 3	13 10 0	13 10 7½	13 12 6	13 11 6	13 10 0	13 8 8½
1929	13 11 0	13 13 1½	13 12 9½	13 10 11½	13 9 3	13 8 9	13 11 6	13 7 6	13 7 6	13 5 6	12 18 9	12 12 9½	13 7 5½
1930	12 5 0	11 15 0	11 19 6	11 18 7	11 18 0	11 17 6	11 17 6	11 17 6	11 16 3	11 12 6	11 8 9	11 5 0	11 15 11½
1931	11 4 0	11 0 0	11 0 0	11 0 0	10 13 9	9 18 9	9 13 0	9 5 3½	8 19 0½	9 16 0	9 8 9	9 4 0½	10 1 10½
1932	9 2 9	9 14 4½	9 16 0	9 13 9	9 12 6	9 12 6	9 11 0	9 4 4½	9 11 3	10 12 6	11 5 0	11 7 0	9 18 7
1933	11 15 0	11 15 0	11 15 0	11 15 0	11 17 6	12 4 0	12 10 0	12 10 0	12 12 6	12 15 0	12 15 0	12 15 0	12 4 11
1934	12 15 0	12 15 0	12 15 0	12 17 6	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	12 18 6½
1935	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 2 6	13 5 0	13 7 6	13 1 3

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